NOVEMBER 1961
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CANADIAN ELECTRONICS ENGINEERING

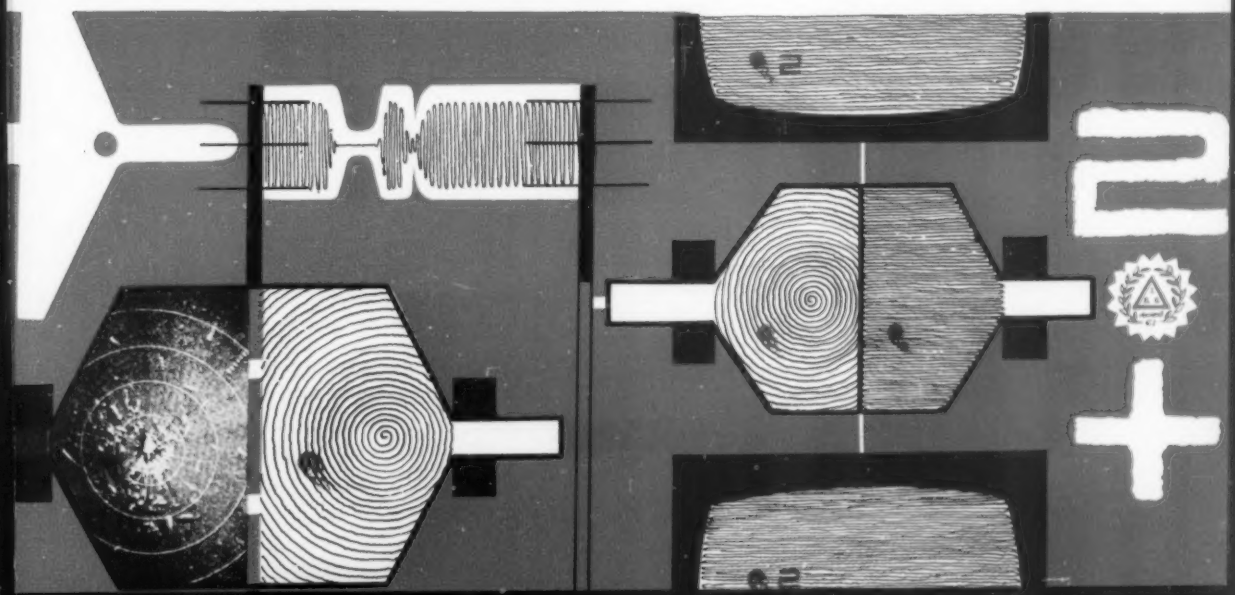
NOV 21 1961

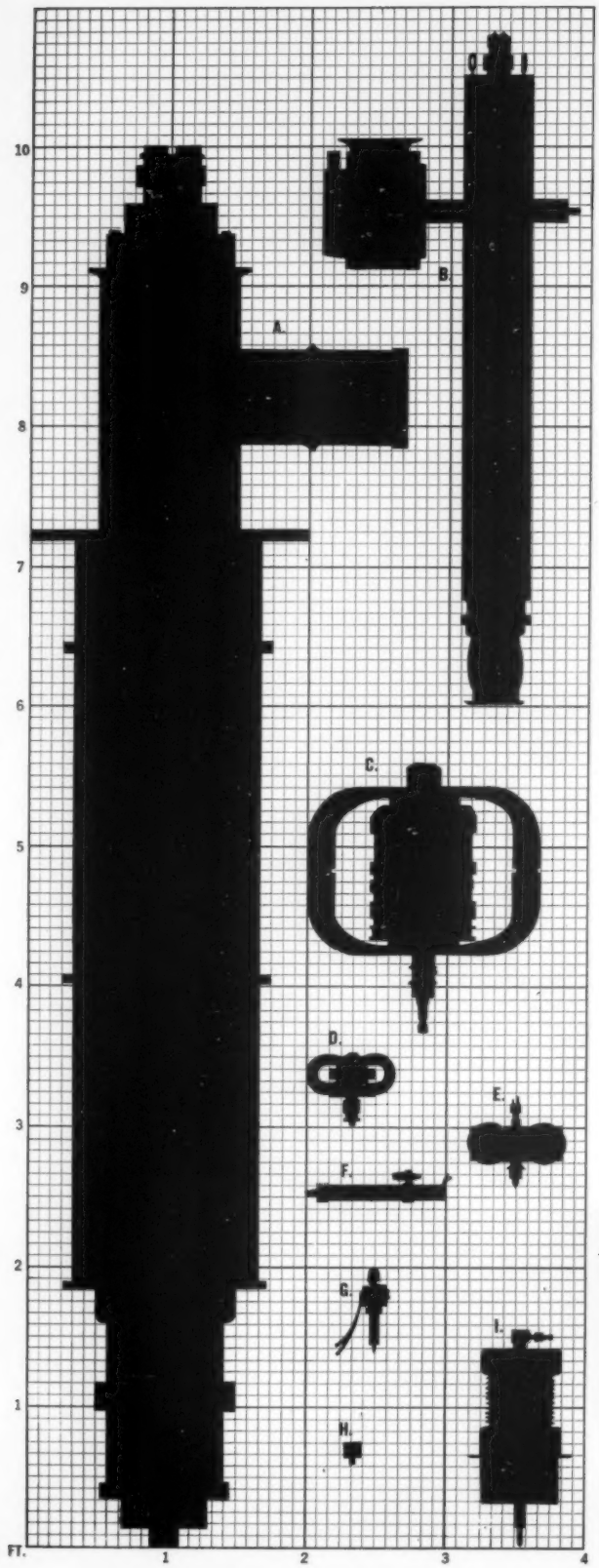
New approach simplifies the design of transistor amplifiers

Notes on the operation of linear diode detectors

Canadian firm expands facilities for rebuilding picture tubes

Slowed-down video can be transmitted over telephone lines





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CANADIAN ELECTRONICS ENGINEERING

Volume five number 11 November 1961

Directorate of industrial research will promote development in Canada — Feature Report — 35

Slowed-down video permits transmission of radar pictures over telephone lines

36

Video signals from an air traffic control radar are converted to less than 1.5 kc bandwidth in a dual-gun storage tube. They can then be transmitted through telephone circuits. At the receiving end, the signals are converted for display on TV monitors.

Symbol generator helps air traffic controllers identify and direct aircraft

Television-type alpha-numeric symbols are generated in this equipment for simultaneous display with converted radar information. Traffic controllers can easily select and position the symbols on their monitor screens. The symbol generator earned for Raytheon Canada Ltd. the award for the best Canadian-designed product exhibited at the 1961 IRE Canadian Electronics Conference. Dr. T. W. R. East (at left in photo) and M. M. Feilchenfeld (centre), co-authors of the article on slowed-down video, join R. W. Dankwardt, principal designer of the symbol generator, in admiring the plaque presented at the Conference.

Dr. T. W. R. East graduated from Cambridge and then worked at TRE, now the Royal Radar Establishment, from 1942 to 1951. He then studied the formation of rain and developed weather radar systems in the Stormy Weather Radar Group at McGill. Since 1958 he has headed the Circuit Design Section at Raytheon Canada Ltd. **M. M. Feilchenfeld,** Dipl. Ing., AMIEE, graduated from Polish University College, London, in 1950, then took a post-graduate course in electronics at Southampton University. Following circuit design work with Murphy Radio Ltd. and J. Langham Thompson Ltd. in England, he joined Raytheon Canada's Circuit Design Section in 1956. **R. W. Dankwardt** was born in Kitchener, Ontario and obtained his BSc in mathematics and physics from Western Ontario in 1953. After working on TV receiver design at Dominion Electrohome Industries Ltd., he joined Raytheon Canada in 1958, and has been designing radar displays.

New approach simplifies the practical design of transistor amplifiers

41

This work is a continuation of some previous studies by the same author, aimed at simplifying the practical design of transistor amplifiers. In the present work, the variation with frequency of amplifier gain receives special attention.

H. L. Armstrong obtained his honors BSc and MSc degrees in physics from Queen's. From 1951 to 1958 he worked in various capacities with the National Research Council, Clevite Corp. and Pacific Semiconductors Inc. He then joined the staff of Queen's, where he is an Assistant Professor in the Dept. of Physics. He is currently completing a textbook on semiconductors, based in part on the work reported in CEE.

The operation of linear diode detectors

46

The basic principles of operation of the "linear" detector are reviewed to clarify some of the confusing non-linearities in the multiple input case. The discussion is introduced by a review of the more important properties of signals and random functions of time. This article is based on data obtained from a wide variety of sources.

J. K. Pulfer has become a regular contributor to CEE, having been a co-author of two articles earlier this year (February, page 40 and July, page 31). Mr. Pulfer was born in Gordon, Manitoba and received his BSc in electrical engineering from the University of Manitoba in 1953. After a year of post-graduate work he joined the National Research Council, where he has been working on defence problems.

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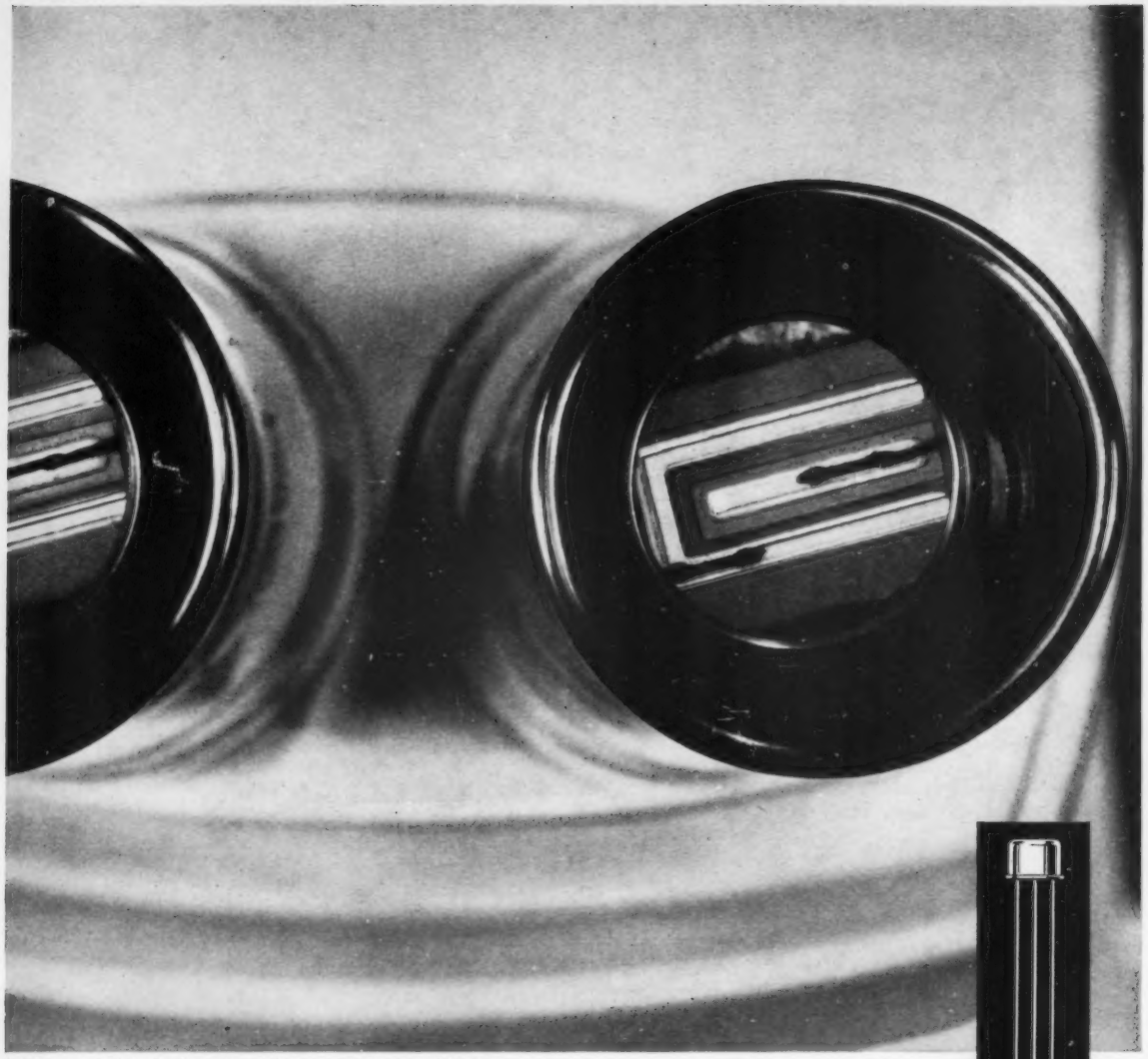

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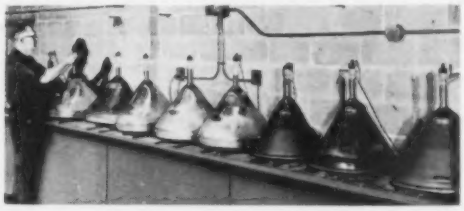
IRE Canadian Electronics Conference reflects industry upsurge in 1961 52

Attendance at the conference set a new record and confirmed previous indicators that the Canadian electronics industry is climbing once more. The panel session on education, shown at right, was one of the best-attended meetings during the three-day conference in Toronto.

Canadian firm expands facilities for rebuilding picture tubes 55

This young Canadian company recently made a public offering of stock to obtain more capital for expansion. With one plant in Canada and two in the United States, the company is building up a large sales volume for its remanufactured TV picture tubes and ignitron tubes.



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NEWS HIGHLIGHTS

EIA reports TV sales up; radio sales dropping due to rising imports.

For the second month in succession members of the Receiver Division of the Electronic Industries Association of Canada have reported that their television sales have increased over the same period last year. In his report last month, F. W. Radcliffe, General Manager of EIA said, "At August 31, the increase stands at 5.4% over the first 8 months of 1960 — 156,403 units versus 148,378 units.

"The industry foresees not only a continuing upswing in sales, but the very real possibility of a shortage. Some manufacturers report they are already oversold on popular models. Inventory at August 31 of the EIA member group is 27.8% below a year ago, the lowest figure in many years.

"In the field of radio, this optimism is reversed due to imports," said Mr. Radcliffe.

"Radio sales for member manufacturers for the 8-month period in 1961, totalled 270,252 compared to 285,115 in the same period in 1960. It represents a drop of 5.2%.

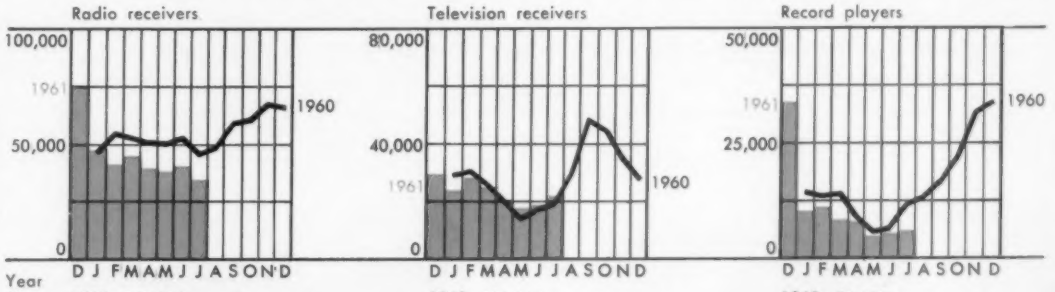
"Record player sales for the first 8 months in 1961 were 63,242 compared to 71,905 in the same period in 1960 — a drop of 12.1%."

RCA Victor receives contract to build equipment for 3,060-mile microwave network linking capitals of Turkey, Iran and Pakistan.

The International Cooperation Administration (ICA) has awarded a $16.4 million contract to the Radio Corp. of America for a 3,060-mile telecommunications network linking Turkey, Iran and Pakistan. Known as the CENTO network, it will provide 600 telephone voice

(Continued on page 7)

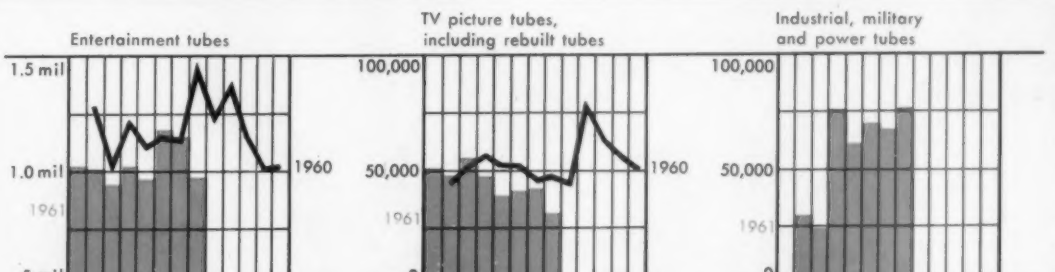
Commencing with this issue, CEE will present statistics on radio, TV, record player and tube production based on Dominion Bureau of Statistics figures, rather than Electronic Industries Association figures used formerly.



Year to date	Radio receivers	Television receivers	Record players
1960	350,172	156,169	74,139
1961	292,222	160,446	58,312

Producers' domestic sales, excluding imports (in units)

Source: Dominion Bureau of Statistics / Charts: CEE

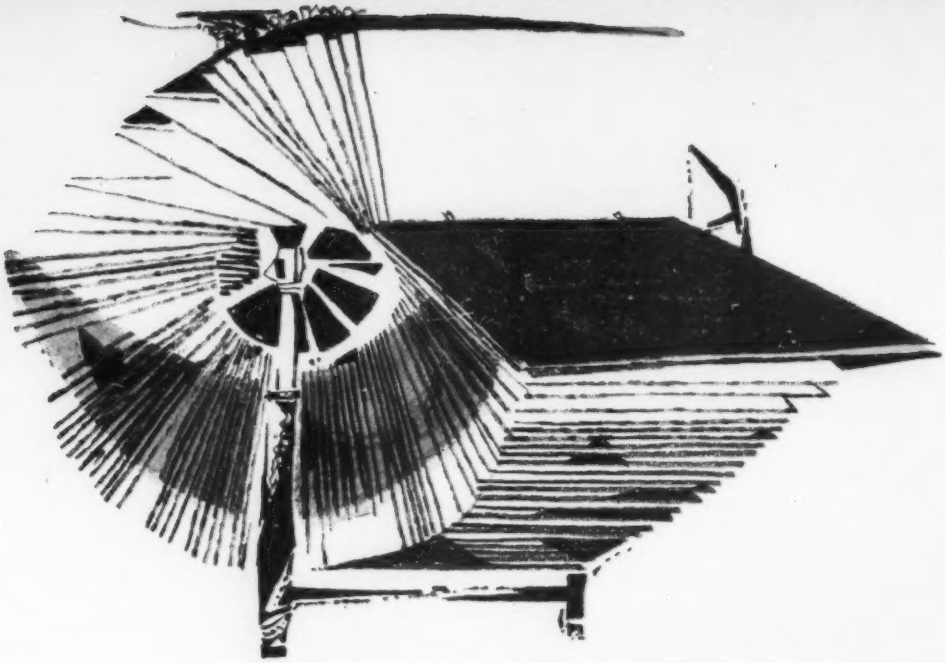


Year to date	Entertainment tubes	TV picture tubes, including rebuilt tubes	Industrial, military and power tubes
1960	8,396,122	352,065	
1961	7,381,818	307,653	407,247

Note: 1960 figures for entertainment type tubes include industrial, military and power types.

Producers' domestic shipments of tubes (in units)

Source: Dominion Bureau of Statistics / Charts: CEE



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channels when completed in the next 30 months. Equipment for the network will be built by RCA Victor Co. Ltd., Montreal, at a cost amounting to nearly one third of the total contract. MM-600 equipment will be used; it is similar to that which was developed for the Alberta-Alaska microwave system.

The Department of Transport is moving its Decca navigator equipment from Quebec City to Anticosti Island.

The Decca navigator equipment formerly located at Quebec is being moved eastward and its master station located on Anticosti Island to better serve shipping in the Gulf of St. Lawrence, and lower St. Lawrence River. The Department of Transport is also planning relocation of the West Newfoundland Decca chain, which will be known as the Cabot Strait Chain and will improve navigation aid in that area.

Collins Radio Co. of Canada has delivered its first UHF emergency transceivers to the RCAF.

The first AN/ARC-504 UHF emergency transceiver was delivered to the RCAF last month. Designed and built at Collins Radio Co. of Canada, they will be installed in the RCAF's CF-104 Super Starfighters. It is also standard equipment on all F-104G and F-104J versions of the aircraft, and negotiations are under way for export of the transceivers to West Germany, Belgium, the Netherlands, Italy, Japan and United States.

Ferranti Ltd. has sold two mammoth Atlas computers and is considering producing future models in Canada.

Claimed to be the world's largest computer, the Atlas can perform about a million simple operations per second. Two are being built now — for the United Kingdom Atomic Energy Authority, and the University of London. The growing North American interest in machines of the size and capabilities of Atlas is resulting in active consideration by Ferranti-Packard of Canadian production of the computer.

Seven new "DEW East" radar stations have been placed in operation.

Seven new stations of the Distant Early Warning (DEW) Line have been placed in operation. Known as DEW East stations, they span a 1,200-mile corridor from Baffin Island in Canada, across Greenland to the Western coast of Iceland. The main DEW Line network stretches nearly 6,000 miles from Baffin Island westward to the Aleutian Islands.

New underwater cable from Tokyo to Hawaii will complete link from Japan to the United States by 1964.

A joint Japanese-American project calls for the World's longest underwater cable stretching 6,200 miles from Tokyo to Hawaii. When completed in June, 1964, the cable will make 128 telephone circuits available each way. The olympic games being held in Tokyo in October of that year will be televised live in the United States through the cable.

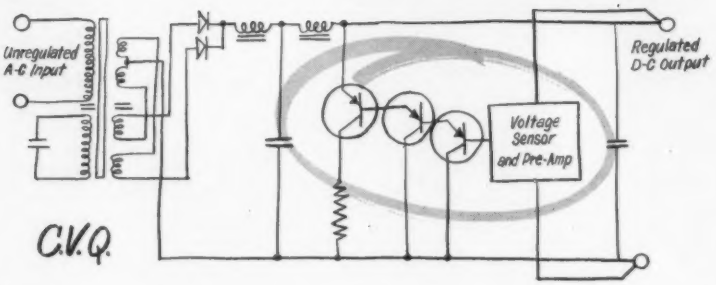
Clairtone Sound Corp. has tripled its sales this year and is having a new plant built in Metropolitan Toronto.

Total sales from January to August, 1961, were more than triple those of the similar 8-month period in 1960. Sales rose from $422,746 to $1,396,772 and, with the traditional heavy selling season of the Fall months, are expected to be between $3½ to $4 million by the end of 1961. "United States sales, which currently make up approximately 1/3 of the total volume, will probably equal or exceed Canadian sales within the next year or two," predicted Peter M. Munk, president of Clairtone. Clairtone is the only Canadian firm in its field to have its own national sales organization in the United States. In addition, sales representation has been established in England, France, Benelux, Switzerland, Germany and Italy.

The company also has exclusive merchandising rights in Canada and the U. S. for all radio-stereo record players manufactured by the Max Braun Co. of Germany. Although marketing was only begun at the start of August, early indications point to a $1 million sales volume in the first 12 months for this line.

Clairtone is having a new plant built on Ronson Drive, just above Highway 401 in Etobicoke (Metropolitan Toronto). The $500,000 building will have 80,000 square feet of floor area when completed.

SOLA writes this new Rx for reliable d-c power



This schematic tells "CVQ's" secret at a glance . . . how SOLA's remarkably reliable new power supply achieves d-c output ideal for computers and other voltage-sensitive equipment. "CVQ" integrates the advantages of shunt-circuit regulation with the *inherent* high stability of the SOLA static-magnetic transformer. And the result is transistorized voltage regulation *with split-cycle response!*

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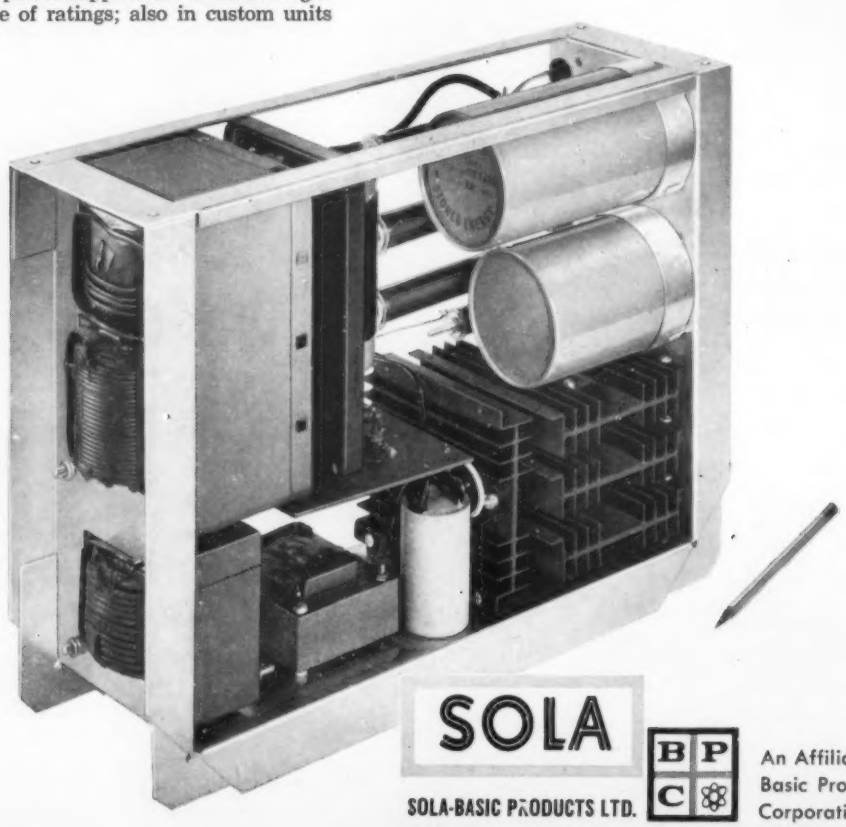
- Output regulated within ±0.04% for line voltage variations ±15%; 0.2% static-load regulation, 0 to full load. Excellent response time.
- Standard models available in the 120-watt range for 5, 6, 10 and 12 volts d-c (100-130/181-235/200-260 volt input).
- Compact mechanical layout — only 12¼ x 5¼ x 19".



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E. R. Huckman is named general sales manager for Foxboro Co.

Edward R. Huckman has been named general sales manager for The Foxboro Co. Ltd. and will have charge of all industrial instrument sales activities for the company. Mr. Huckman is a graduate of the Massachusetts Institute of Technology with a BS degree. He joined Foxboro in 1927, and for the past three years has been assistant field sales manager for the U.S. sales organization.

Huckman

Onn

William R. Onn has been appointed chief engineer of CKEY, Toronto.

Mr. Onn has been associated with the technical aspects of broadcasting for the past 14 years. Most recently, he was chief engineer of CHLO, St. Thomas, Ontario, a position he held for 9 years. He was chairman of the Engineering Section of the Central Canada Broadcasters' Association for 3 years, and he has been an active supporter of the London Section of IRE.

Joe S. Kirk has rejoined National Electronics, Inc. as manager of commercial engineering.

Mr. Kirk has been in the industrial tube business for 15 years and was previously located at Continental Electric, National Electronics, and most recently, at Sandia Corp. He has been in close association with the Canadian electronics industry during that period.

E. L. Palin has been appointed Technical Training Specialist by the Ontario Department of Education.

Mr. Palin has resigned as Administrative Assistant, Ryerson Institute of Technology, Toronto, to take on his new duties with the Ontario Department of Education. In his new position, Mr. Palin will be responsible for assisting Ontario trade, technical and vocational schools in establishing and improving technical training.

Mr. Palin has had a long and successful association with education and the electronics industry. He is a former chairman of the Toronto Section of IRE, and served as general chairman of the 1959 IRE Canadian Convention and Exposition.

James R. MacKay has been appointed Chief, Design and Construction Div., Telecommunications and Electronics Branch, Department of Transport.

Joining the Radio Div. in 1938, Mr. MacKay has been closely associated with the development and expansion of air navigation radio aids and has been associate Chief of the Design and Construction Div. for the past two years. He succeeds H. E. Walsh who recently retired on superannuation.

Transitron appoints Frank J. Wilkins as field sales engineer in new Montreal office.

Transitron Electronic Corp. of Canada Ltd. has established an office at 2774 Kant St., Montreal, and appointed Mr. Wilkins as field sales engineer. Mr. Wilkins formerly was associated with Collins Radio Co. of Canada Ltd., and Canadian General Electric Co. Ltd. in Toronto.

Whittaker Electronics Ltd. has appointed Fred Cameron and Harvey Halverson as head office representatives.

Mr. Cameron's background includes design work of mechanical and electro-mechanical devices with Canadian Signals Research and Development Establishment, Sangamo Co., and Computing Devices of Canada Ltd.

Mr. Halverson was previously associated with Measurement Engineering Ltd., where he was engaged in purchasing and contract administration activities.

William R. McLellan will represent Precision Instrument Co. in Canada.

Mr. McLellan, a senior systems engineer with Precision Instrument Co. of San Carlos, Calif. will be located at 880 Lady Ellen Place, Ottawa. He will be the technical representative in Canada for this manufacturer of instrumentation magnetic recorders.

Prior to assuming his new duties, Mr. McLellan was employed in the design, development, and procurement of data handling systems for the RCAF test range in Alberta. Earlier, he served as senior electronics engineer with LEO Computers Ltd., England. He has also been associated with the British Tabulating Machine Co. in Northern Ireland, and with the Research and Development Labs of Short Brothers and Harland Ltd.

Honeywell's Keith Warne is chosen "advertising manager of the year"

Industrial Sales/Promotion publication recently asked more than 200 business paper advertising representatives to name "the advertising manager of the year." Keith Warne, 33-year-old merchandising manager of Honeywell Controls Ltd., Toronto, topped the list.

Said one space rep: "He looks beyond circulation and rate cards at editorial. He's a sophisticated — but tough — buyer, and he has the ability to think objectively and not subjectively when he looks at media.

Gordon B. Tebo has been named as a Fellow of the American Institute of Electrical Engineers.

Mr. Tebo is manager of the Canadian Standards Association Testing Laboratories in Toronto. He was elevated to the rank of Fellow in recognition of ". . . contributions to research and to developments relating to the safe use of electric power." He was one of six members recently honored by AIEE.

R. H. Garretson has been appointed to the board of directors of Bell & Howell Canada Ltd.

He is executive vice-president of Bell & Howell Co., Chicago, president of Consolidated Electrodynamics Corp., Pasadena, Calif. (a Bell & Howell subsidiary), and vice chairman of the board of Consolidated Vacuum Corp. (a CEC subsidiary).

Florence Hurtubise has been appointed to the Montreal sales office of Renfrew Electric Co.

Mrs. Hurtubise's experience in the electronics industry commenced in 1944 as a buyer for RCA Victor Co. Ltd. In 1951 she was made purchasing agent for their Home Instrument Div. In 1957 she joined Dominion Electrohome Industries as purchasing agent for the Electrohome Products Div. Her appointment as supervisor of Government Sales with Canadian Electrical Supply came in 1958 and continued until her recent appointment with Renfrew. Mrs. Hurtubise is presently attending Sir George Williams University to obtain a BA degree.

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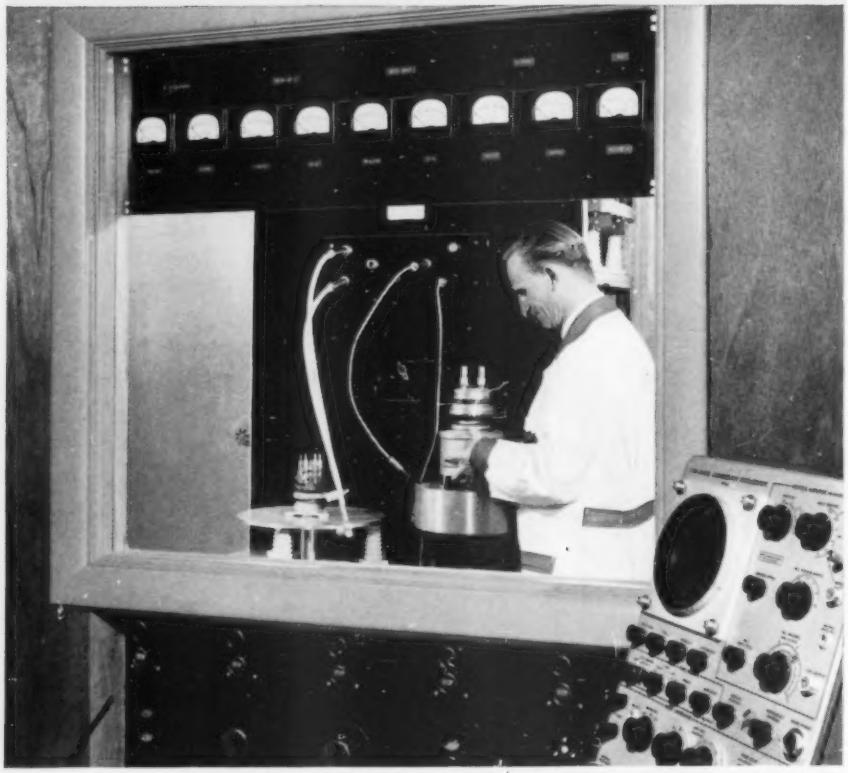
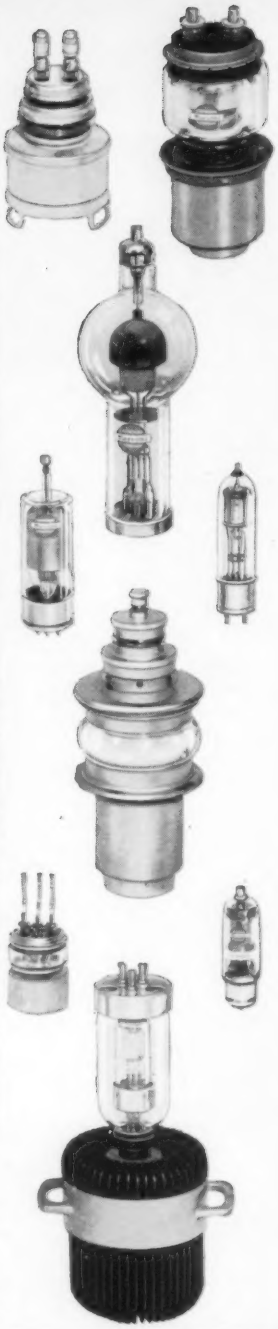


Special Purpose Tubes are tested under simulated operating conditions at the new Marconi Test Lab in Toronto—only lab of its kind in Canada. Here a technician connects a BR1102 Tube in a special pressure-controlled test room.

This means new convenience in Special Purpose Tube service for you. If you are in one of the many industries now using Special Purpose Tubes in complicated equipment you know how important this can be . . . how your whole operation can be held up while you wait for replacement or adjustment of a faulty tube. This is because these tubes are *normally* imported by a distributor and shipped to the customer *without* testing. *Not so a Marconi Special Purpose Tube.* Tubes are pre-tested in the new, fully-equipped Marconi Test Lab . . . sealed and protected by the Marconi warranty. If any trouble does occur, you can be sure of *immediate* warranty adjustment. Marconi electronics specialists will give you on-the-spot assistance. This service is as close as your phone.



Canadian Marconi has the widest and most complete range of Special Purpose Tubes in Canada. Marconi's extensive background of experience in electronic tubes and equipment can prove invaluable to you in the selection and use of proper tubes and components for your requirements.

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Andrew expands manufacturing facilities at Whitby, Ontario

A new factory and office area, more than four times larger than the previous area, will permit Andrew Antenna Corp., Whitby, Ont., to build and stock a wider range of its antennas and allied equipment. New products, such as large aluminum waveguide and parabolic antennas larger than 10 feet in diameter, will be fabricated at the Canadian plant for the first time. Additions to test facilities now allow pre-production and production testing of components in all commercial bands, including the 7 Gc microwave band.

European technicians take simulator maintenance course

Six German Air Force NCOs have arrived in Montreal to attend a flight simulator maintenance training course at the headquarters of Canadian Aviation Electronics Ltd. The group forms the second class in the course which will see about 150 experts trained to maintain the simulators.

CAE is building about 25 simulators for F-104 airplanes for the RCAF and the Governments of West Germany and the Netherlands.

Special instrumentation is being developed for CARDE research

Special instrumentation to study missile re-entry is being developed by the Electro-Optical Division of Perkin-Elmer Corp., under contract to the U. S. Army Rocket and Guided Missile Agency (ARGMA). The instrument will be used in studies of simulated re-entry conditions at the Canadian Armament Research and Development Establishment (CARDE), in Quebec City.

Investigation conducted by Canadian and U. S. scientists at CARDE underlie both anti-missile design and development of ICBM warning systems.

The Perkin-Elmer contract involves a study program and development of instrumentation. One goal, for example, is to develop techniques for complete infrared scan of a projectile in one-millionth of a second.

Astral Electric Co. Ltd., Cook Records Canada and Ungar Electric Tool Co. of Canada now form the Electronics Division of Eldon Industries of Canada Ltd., Scarborough, Ont. Seen examining the Imperial soldering iron introduced at the IRE show are, l to r, A. J. MacLean, plant manager; Dennis E. Tiberiis, v-p and general manager; D. W. Rippin, manager of the new division.

Honeywell Controls supply instruments to Mexico

Recording, indicating and control equipment has been supplied by Honeywell Controls Ltd., Toronto, to Petroleos Mexicanos for the new Madero petroleum refinery.

CESCO changes its name

Cesco Electronics Ltd. has become the new name of Canadian Electrical Supply Co. Ltd. The original name was first registered in 1917, and for many years the company's primary business was the sale of electrical equipment. The change of name was the natural outcome of the nature of today's business for the company.

Cesco Electronics Ltd. is now stocking United Transformer industrial and dealer type transformers; and Halicrafters receivers and transceivers. These are included in the new 1962 catalogue available from all branches of Cesco Electronics.

New principals, representatives and services

Whittaker Electronics Ltd. has been appointed to represent **Industrial Electronics Engineers, Inc.,** North Hollywood, in Central and Eastern Canada. Products include readouts and visual signals.

Tele-Radio Systems Ltd. has been appointed exclusive Canadian representative for **Advanced Measurement Instruments, Inc.** of Somerville, Mass, makers of deviation monitors, signal generators and specialized test equipment. The company has also been appointed representative for **Centralized Data Control, Inc.,** Roslyn, N.Y., producers of tone channelling equipment and other telemetering equipment.

(Continued on page 66)

Ottawa report

A growing volume of defence contracts from the United States to Canada (a result of joint government policies) is reported by Defence Production Minister Raymond O'Hurley.

Production sharing contracts for the first eight months of 1961 totaled $79.9 million, compared to $55 million worth of U. S. defence business placed in Canada during the same period last year. This year's total is made up of $43 million in prime contracts and $36.8 million in subcontracts.

O'Hurley reviewed defence sharing and the program for assistance to industry during discussion of his estimates in the Commons.

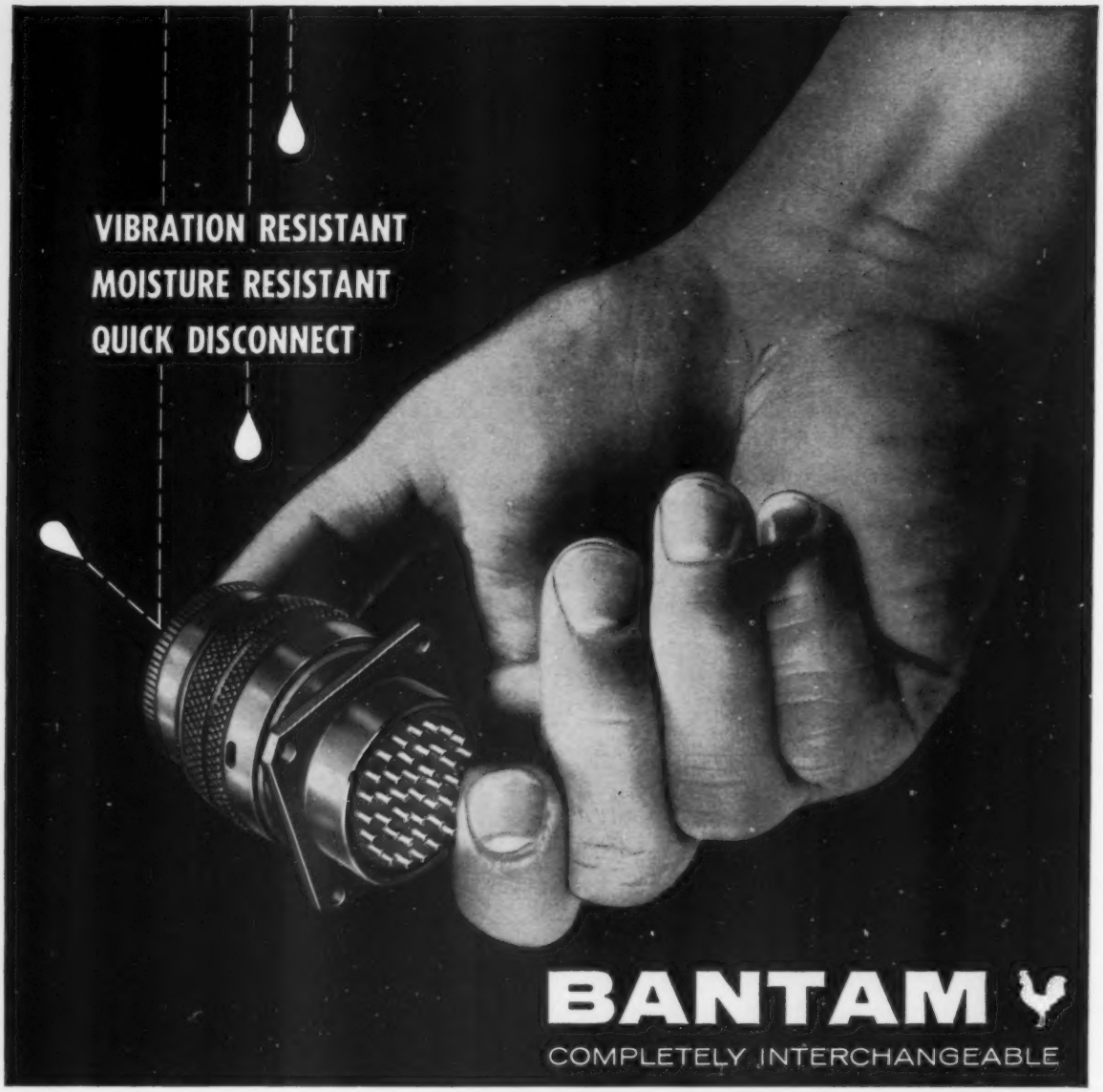
The sum of $5.5 million has been set aside during the current fiscal year for development cost sharing, up from $5 million in 1960-61. This program is intended to assist with development work so as to maintain technological developments at a level that will later result in defence export contracts.

He said that to Aug. 31 this program had resulted in the government contributing about $20.1 million to development projects either awarded Canadian companies or awaiting formal approval. In addition there were a number of projects under active consideration, worth about $4.6 million, "including several unique Canadian concepts and formal U. S. requirements approved in principle for support." There were also a "variety of development possibilities under preliminary investigation."

Not included in this list were some $13.7 millions worth of U. S. research, development and technical engineering assistance contracts.

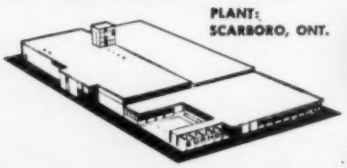
As examples of major projects under this program O'Hurley cited the V/STOL aircraft by Avro, Canadair and De Havilland; turbine engines by Orenda and Pratt and Whitney; airborne electronic equipment by Marconi and Computing Devices of Canada; radar items by Long Sault Woodcraft and Fleet Manufac-

(Continued on page 67)



miniature solder connectors certified to MIL-C-26482 (ASG)

Up to 32 contacts in an area the size of a ... providing for 61 contacts in an area slightly larger, the Bantam line is available in a wide variety of insert configurations and shell sizes. Extra heavy gold plating, 75 micro inches — far exceeding current specifications provides extra protection against corrosion. The Bantam contacts also provide hard gold mating against soft gold adding durability and minimizing galling. An exclusive wire-seal grommet will seal all required wires and in addition type EE Mil-W-16878. Electrically, mechanically, BANTAM connectors have proven completely dependable. Copper alloy closed entry sockets, extra heavily gold-plated over silver... moisture-proof resilient inserts... cadmium-plated shells of impact-extruded aluminum... heavy spring tension for perfect interface sealing.



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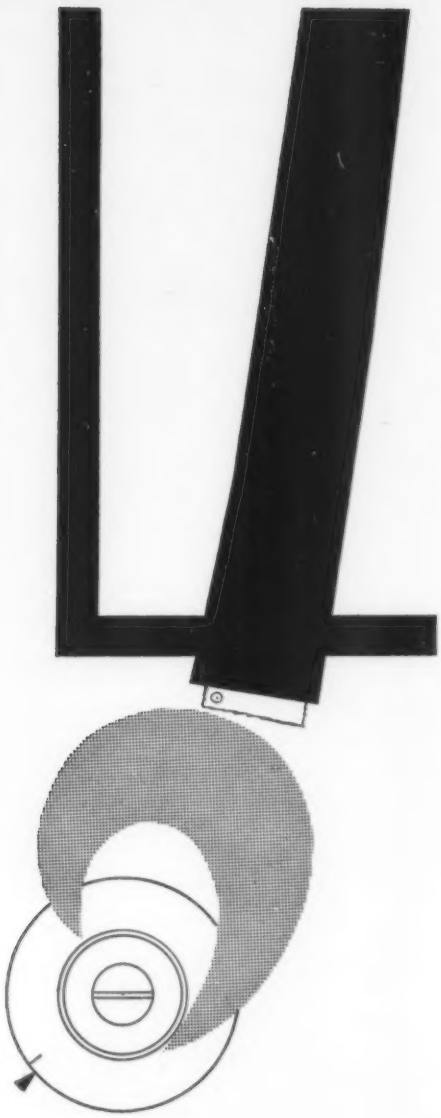

cae

A Canadian Company...

Canadian Aviation Electronics Ltd. is a 14-year-old company with headquarters in Montreal and plants in Montreal and Winnipeg. It is engaged in the design, development and manufacture of complex electronic equipment for industry and defence:—the calibration, repair and overhaul of electronic equipment:—and maintenance work on North American early warning radar lines. It supplies products and services to the governments of five countries on two continents and provides jobs for more than 1,500 Canadians.

Flight simulators designed and built by CAE have been used to train hundreds of pilots for the RCAF, the Belgian Air Force and Canadian Pacific Air Lines and the company is presently working on orders for approximately 25 F-104 "Starfighter" simulators for the RCAF and the governments of West Germany and the Netherlands.

CAE electronic systems are being used in Canadian industries from coast to coast and engineers and scientists in the company's research and development establishment are constantly designing new equipment to make industry more productive and Canada more secure.

CANADIAN AVIATION ELECTRONICS LTD.

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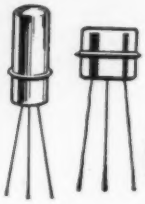

COVERS THE ENTIRE USEFUL

MICRO ALLOY DIFFUSED-BASE TRANSISTORS (MADT*)

TYPE	GAIN h_{FE}	FREQUENCY f_{max} in mc	APPLICATIONS
2N499	10 db @ 100 mc	320	VHF amplifier; MIL specifications
2N501	70	Switching rates 20 mc	Ultra-fast switch; typical t_r 11 mμsec, t_s 8 mμsec, t_f 8 mμsec
2N501A	95	Switching rates 20 mc	Ultra-fast switch; typical t_r 10 mμsec, t_s 7 mμsec, t_f 7 mμsec; MIL specifications
2N502	12 db @ 200 mc	800	VHF amplifier and oscillator
2N502A	12 db @ 200 mc	800	Rated at 100°C; MIL specifications
2N503	12.5 db @ 100 mc	350	VHF amplifier
2N888	14 db @ 50 mc	250	General purpose RF-IF amplifier
2N768	40	f_T 175	High-frequency micro-energy switch
2N769	55	f_T 900	Ultra-fast switch for low-level, high-frequency logic circuits
2N779A	90	Switching rates 20 mc	Very high-speed switch
2N846A	50	Switching rates 20 mc	Very high-frequency switch
2N1158	30 mw PO	at 200 mc	VHF power oscillator
2N1158A	35 mw PO	at 200 mc	VHF power oscillator; MIL specifications
2N1204	30	Switching rates 25 mc	High current switch & core driver
2N1494	30	Switching rates 25 mc	High current, high power switch & core driver
2N1495	30	Switching rates 25 mc	Higher voltage version of 2N1204
2N1499A	70	Switching rates 10 mc	High-speed, saturated switch; MIL specifications
2N1500	70	Switching rates 20 mc	Ultra-fast switch; typical t_r 13 mμsec, t_s 7 mμsec, t_f 7 mμsec; MIL specifications
2N1726	60	150	6-12 volt radio RF amplifier
2N1727	60	150	6-12 volt radio converter
2N1728	60	150	6-12 volt radio IF amplifier
2N1742	33	1300	UHF and VHF amplifier
2N1743	33	1300	UHF and VHF mixer
2N1744	33	2.5 mw PO at 257 mc	VHF oscillator
2N1745	33	800	45 mc IF amplifier
2N1746	60	235	4.5 mc unneutralized IF amplifier
2N1747	60	250	6-12 volt radio FM IF amplifier
2N1748	h_{fe} 45	f_T 115	Video driver
2N1748A	h_{fe} 70	f_T 132	Video driver; higher beta 2N1748
2N1749	h_{fe} 45	f_T 115	Video output; higher voltage 2N1748
2N1752	h_{fe} 250	106	High beta TV sync separator
2N1754	75	Switching rates 10 mc	High-speed saturated switch
2N1785	60	125	3 to 6 volt radio RF amplifier
2N1786	60	125	3 to 6 volt radio converter
2N1787	60	125	3 to 6 volt radio IF amplifier
2N1788	60	150	12 volt auto radio RF amplifier
2N1789	60	150	12 volt auto radio converter
2N1790	60	150	12 volt auto radio IF amplifier
2N1864	50	125	Reflex amplifier in broadcast receivers
2N1865	60	250	6-9 volt radio AM/FM IF amplifier
2N1866	60	250	12 volt auto radio AM/FM IF amplifier
2N1867	60	250	12 volt auto radio FM IF amplifier
2N1868	33	800	45 mc TV IF amplifier; 19 db PG @ V_{CE} = —4.5v

MICRO ALLOY TRANSISTORS (MAT*)

TYPE	GAIN h_{FE}	FREQUENCY f_T in mc	APPLICATIONS
2N393	50	50	High-speed, high-gain switch; MIL specifications
2N1122	50	60	High-voltage, high-speed switch
2N1122A	50	60	Higher voltage version of 2N1122
2N1411	50	50	High-frequency switch; MIL specifications
2N1427	75	75	General purpose, high-speed switch

SILICON SURFACE ALLOY TRANSISTORS (SAT*)

TYPE	GAIN h_{fe}	FREQUENCY f_{max} in mc	APPLICATIONS
2N493	35	18	General purpose; MIL specifications
2N496	h_{FE} 25	f_T 20	High-speed switching; MIL specifications
2N1118	35	18	General purpose; MIL specifications
2N1118A	25	18	General purpose amplifier, high beta (15-35)
2N1119	h_{FE} 25	f_T 20	High-speed switching; MIL specifications
2N1428	45	23	General purpose, low-cost, high-frequency, silicon amplifier and switch; TO-1 case
2N1429	45	23	General purpose, low-cost, high-frequency, silicon amplifier and switch; TO-5 case
2N1676	50	42	Chopper at rates in excess of 50kc
2N1677	50	32	Chopper at rates in excess of 40kc

SILICON SURFACE ALLOY DIFFUSED-BASE TRANSISTORS (SADT*)

TYPE	GAIN h_{fe}	FREQUENCY	APPLICATIONS
2N770	h_{FE} 25	Switching rates 5 mc	NPN high-speed switch with controlled switching characteristics
2N771	h_{FE} 50	Switching rates 5 mc	NPN high-speed switch with controlled switching characteristics
2N772	h_{FE} 35	Switching rates 5 mc	NPN high-speed switch with controlled switching characteristics
2N773	11	25 db at 4.3 mc	NPN narrow and wide band 4.3 mc video amplifiers
2N774	20	25 db at 4.3 mc	
2N775	50	25 db at 4.3 mc	
2N776	11	25 db at 12.5 mc	NPN narrow and wide band 12.5 mc video amplifiers
2N777	20	25 db at 12.5 mc	
2N778	50	25 db at 12.5 mc	
2N1199	h_{FE} 25	f_T 125 mc	NPN high-speed silicon switch; max t_r 70 mμsec, t_s 20 mμsec, t_f 40 mμsec
2N1199A	h_{FE} 25	f_T 125 mc	NPN high-speed silicon switch; max t_r 55 mμsec, t_s 20 mμsec, t_f 35 mμsec; MIL specifications
2N1267	11	25 db at 4.3 mc	NPN silicon amplifiers and oscillators
2N1268	20	25 db at 4.3 mc	
2N1269	50	25 db at 4.3 mc	
2N1270	11	25 db at 12.5 mc	NPN silicon amplifiers and oscillators
2N1271	20	25 db at 12.5 mc	
2N1272	50	25 db at 12.5 mc	
2N1472	h_{FE} 35	Switching rates 5 mc	NPN high frequency switch
2N1663	h_{FE} 50	Switching rates 5 mc	NPN high frequency switch

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ONTARIO
Electro Sonic Supply Co. Ltd.,
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complete line of transistors!

FREQUENCY SPECTRUM

SILICON PRECISION ALLOY TRANSISTORS (SPAT**)

TYPE	GAIN h_{FE}	FREQUENCY f_T in mc	APPLICATIONS
2N858	20	14	Medium-speed transistor for control and switching circuits
2N859	35	14	Medium-speed transistor for control and switching circuits and high gain amplifiers
2N860	20	14	Medium-speed transistor for control and switching circuits
2N861	35	22	Medium-speed transistor for control and switching circuits and high-gain amplifiers
2N862	20	14	Medium-speed transistor for control and switching circuits
2N863	35	22	Medium-speed transistor for control and switching circuits and high-gain amplifiers
2N864	35	22	Medium-speed transistor for control, switching and chopper circuits
2N865	75	52	High gain DC and audio amplifiers and control circuits

SURFACE BARRIER TRANSISTORS (SBT**)

TYPE	GAIN h_{fe}	FREQUENCY f_{max} in mc	APPLICATIONS
2N128	40	60	General communications; MIL specifications
2N232	22	50	IF amplifier for AM radios
2N240	30	Switching rates 20 mc	High-speed switch; controlled hole storage and saturation characteristics; MIL specifications
2N344	22	50	General purpose; narrow beta spread (11-33)
2N345	35	50	General purpose; similar to 2N344 with higher beta
2N346	35	75	General purpose; like 2N344 and 2N345 but higher frequency
2N1750	h_{FE} 40 max	50	Horizontal oscillator in television receivers

MINIATURE TRANSISTORS

TYPE	GAIN h_{fe}	FREQUENCY f_{hfb} in mc	APPLICATIONS
2N207	100	2	Low level amplifier; particularly suited for hearing aid use; N.F.† 15 db max
2N207A	100	2	Low level amplifier; particularly suited for hearing aid use; N.F.† 10 db max
2N207B	100	2	Hearing aid input stage; other extremely low noise applications; N.F.† 5 db max
2N534	100	1	High voltage amplifier switch
2N535	100	2	Low-level amplifier and switch; N.F.† 10 db max
2N535A	100	2	Low-level amplifier and switch; N.F.† 5 db max
2N535B	100	2	Low-level amplifier and switch; N.F.† 0 db max
2N536	h_{FE} 150	2	Low-level switch at pulse rates up to 150kc

MEDIUM FREQUENCY TRANSISTORS

TYPE	GAIN h_{FE}	FREQUENCY f_{hfb} in mc	APPLICATIONS
2N397	70	8	Medium power general purpose amplifier and switch
2N398	125	f_T 8	400kc logic switching
2N599	175	f_T 16	Logic switching rates up to 1 mc; core driver MIL specifications
2N600	125	f_T 8	500kc switching; 1 watt peak power dissipation for 0.1 sec; stud mount
2N601	175	f_T 16	High-power core driver; typical rise time 0.1 μsec; stud mount
2N1123	70	5	High-voltage power amplifier and switch; stud mount
2N1478	70	8	300kc switching applications

PULSE AMPLIFIER TRANSISTORS

TYPE	GAIN h_{FE}	FREQUENCY f_{hfb} in kc	APPLICATIONS
2N670	160	700	High peak current pulse amplifier; relay driver
2N671	160	700	High power version of 2N670; stud mount
2N672	Min 20 (SAT)	0.5 μsec max t_γ	High-current switching core driver; controlled rise, fall and store times
2N673	Min 20 (SAT)	0.5 μsec max t_γ	High power version of 2N672; stud mount
2N674	160	1100	75 volt version of 2N670
2N675	160	min 400	75 volt version of 2N671

MEDIUM POWER TRANSISTORS

TYPE	GAIN h_{FE}	FREQUENCY f_{hfb} in kc	APPLICATIONS
2N223	h_{fe} 110	600	Audio driver; exceptional beta linearity
2N1416	h_{fe} 110	600	Matched pair of 2N223's
2N224	90	510	Audio output; exceptional beta linearity
2N225	90	510	Matched pair of 2N224's
2N226	60	400	Audio output and switch; exceptional beta linearity
2N227	60	400	Matched pair of 2N226's
2N1124	h_{fe} 125	1300	High-voltage, general-purpose industrial amplifier and switch
2N1125	95	2000	High-voltage, medium-frequency amplifier and switch
2N1128	h_{fe} 120	1250	Exceptionally linear beta; audio driver and output
2N1129	165	750	General-purpose, high beta, audio and switch
2N1130	110	950	General-purpose audio and switch; exceptional beta linearity

POWER TRANSISTORS

TYPE	GAIN	FREQUENCY f_{hfe} in kc	APPLICATIONS
2N386	33 db at 5w PO	14	High-voltage, high-power amplifiers, servo amplifiers, converters and switches
2N387	33 db at 5w PO	12	High-voltage, high-power amplifiers, servo amplifiers, converters and switches

*Trademarks Reg. U.S. Pat. Off.
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†Noise Figure at 1 μv reference level across 1,000 ohms

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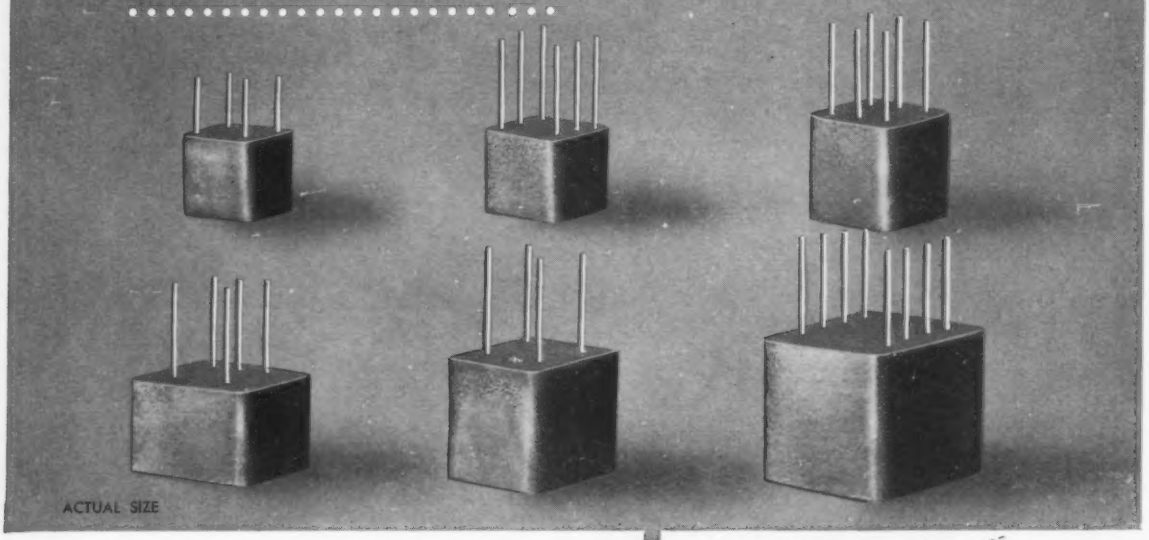
HAMMOND

EPOXY CAST MINIATURE TRANSFORMERS



Vacuum sealed in epoxy resin by an exclusive Hammond process, these rugged lightweight transformers easily meet Grade 5 Class S requirements of MIL-T-27A. Excellent for printed circuit applications by reason of their small mass; and where stock sizes are not adaptable, special sizes, shapes and lead configurations can be quickly supplied at moderate cost.

102 SERIES: available in 3 stock types.

104 SERIES: available in 12 stock types.

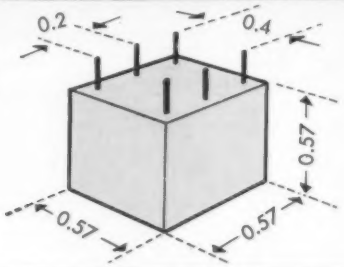
106 SERIES: available in 19 stock types.

Standard types of audio transformers cover a range of impedances and power levels suitable for input, interstage or output applications. Units designed for push-pull use have bifilar wound, centre tapped windings to maintain close tolerance on balance.

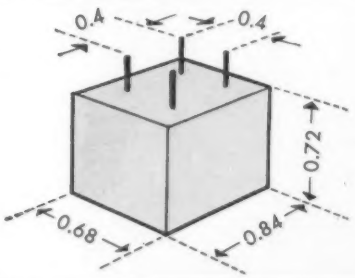
The Hammond epoxy casting technique is applicable to pulse transformers, power transformers and reactors as well as to audio types. The performance of such parts under extreme conditions of temperature, humidity, shock, vibration, and altitude suggests their consideration as a possible alternative to hermetically sealed construction.

HAMMOND
EPOXY INSULATED
TRANSFORMERS
Standard Items Stocked by Leading Jobbers

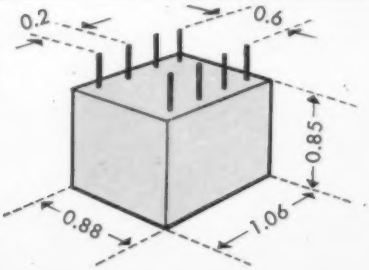
102 SERIES



104 SERIES



106 SERIES



H.6

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New Bourns Precision Potentiometer Resolves the Quality-Price Dilemma!

NUMBER 18—NEW PRODUCT SERIES

Here is military reliability in a competitively-priced industrial potentiometer. Bourns wirewound 10-turn Model 3500 measures just ⅞" in diameter by 1" long—shorter by ½" than units available elsewhere—yet has a resistance element 20% longer than that of comparable potentiometers.

Fully meeting military requirements for steady-state humidity, Model 3500 can also be provided at a 10% premium to meet the cycling humidity specs of MIL-STD-202, Method 106. It's the only ⅞" 10-turn potentiometer guaranteed to meet this spec. Its published characteristics incorporate wide safety margins.

Reliability insurance is provided by the exclusive Bourns Silverweld® bond between terminal and resistance wire. Virtually indestructible under thermal or mechanical stress, this termination eliminates a chief cause of potentiometer failure. In addition, a special close-tolerance rotor almost completely does away with backlash.

Model 3500 is also subjected to the rigorous double-check of Bourns' exclusive Reliability Assurance Program. In short, every possible step is taken to ensure that the performance you specify is the performance you get. Write for complete data.

Resistances	500Ω to 125K, ±3%, std. (to 250K spl.)
Linearity	±0.25% std.
Power rating	2w at 70°C
Operating temp.	−65° to +125°C
Mech. life	2,000,000 shaft revolutions

BOURNS (CANADA) LTD.
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Manufacturer: Trimpot® potentiometers; transducers for position, pressure, acceleration. Plants: Riverside, California; Ames, Iowa; and Toronto, Canada

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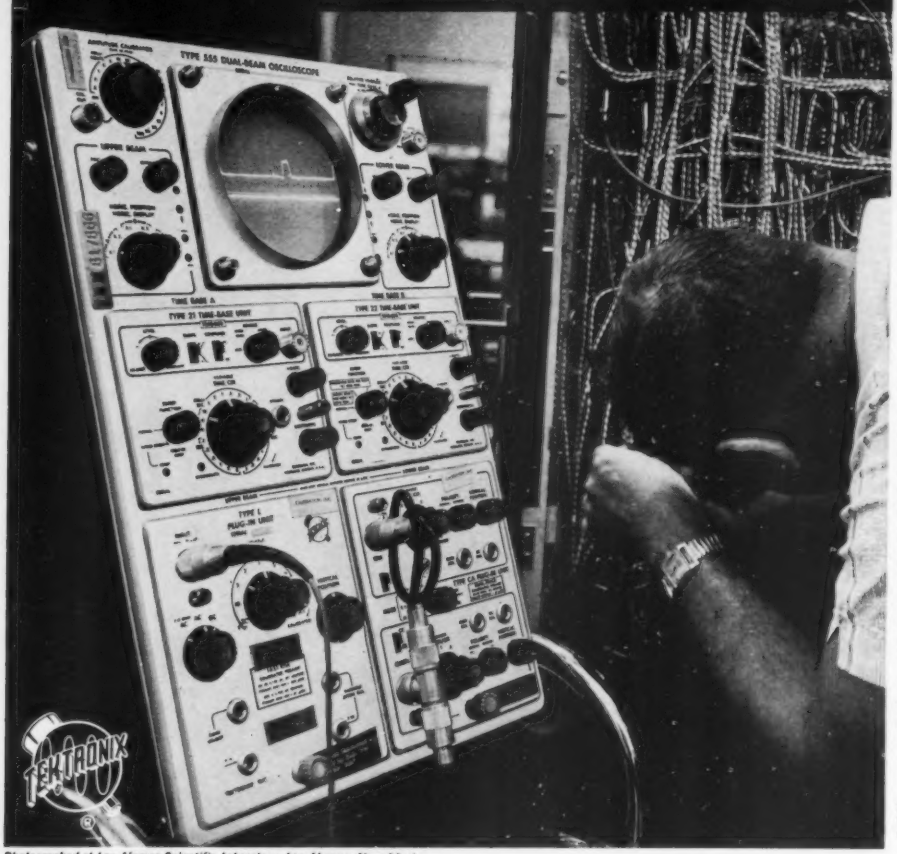
Checking Computer Storage Units

with a

Tektronix Dual-Beam Oscilloscope



Photographed at Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

Engineers at the Los Alamos Scientific Laboratory in New Mexico presently use a Tektronix Type 555 Dual-Beam Oscilloscope for checking out the magnetic-core storage units in Stretch, the new high-speed computer. Upper trace is a storage pulse from one of the units. Lower trace is free-running, awaiting the next storage pulse switched in by the computer.

Six of these magnetic-core storage units constitute the basic *memory* of Stretch, reputed to be the world's most powerful computer. The computer *memory* can store 98,304 words of information, equivalent to more than 1,500,000 decimal units—with data retrievable electronically from any unit in approximately 2 microseconds.

Designed and built for the Laboratory by IBM, in cooperation with the Laboratory's Theoretical Division staff members, Stretch permits scientists to work with far more realistic weapons simulations than in the past, and to analyze the vast amount of data gathered during the tests of nuclear rocket propulsion reactors.

For your own scientific tests and measurements—in analyzing waveforms in the dc-to-30 mc range—you will find a Tektronix Type 555 Dual-Beam Oscilloscope extremely adaptable and reliable. You can use it to display almost any signal in almost any laboratory application.

To observe the signal-handling ease and capabilities of this dual-beam oscilloscope in your own laboratory application, **please call your Tektronix Field Engineer. He will gladly arrange a demonstration for you at your convenience.**

CHARACTERISTICS

Independent X and Y Deflection • DC-to-30 MC, 12-nsec Risetime with Fast-Rise Plug-In Units • 21 Calibrated Sweep Rates from 0.1 μsec/cm to 5 sec/cm • 5X Magnifier • Single-Sweep Provision • Calibrated Sweep Delay • Amplitude-Level (Manual) Selection or Fully Automatic Triggering Facilities • 10-KV Accelerating Potential • 4-cm by 10-cm Display for Each Beam, with 2-cm Overlap • Amplitude Calibrator.

CAPABILITIES

With a Tektronix Type 555 Dual-Beam Oscilloscope, you can control either or both beams with either time-base generator. You can operate one time-base unit as a delay generator—hold off the start of any sweep generated by the other for a precise interval from one-half microsecond to 50 seconds—and observe both the original display and the delayed display at the same time.

By interchanging any combination of 17 letter-series plug-in units, you have signal-handling versatility in such applications as dual-beam pulse-sampling . . . transistor-risetime testing . . . semiconductor-diode-recovery-time studies . . . strain gage and other transducer measurements . . . differential-comparator displays . . . as well as multiple-trace work in general laboratory experiments.

The Type 555 can mean better engineering for you—in less time.

Type 555.....$2600
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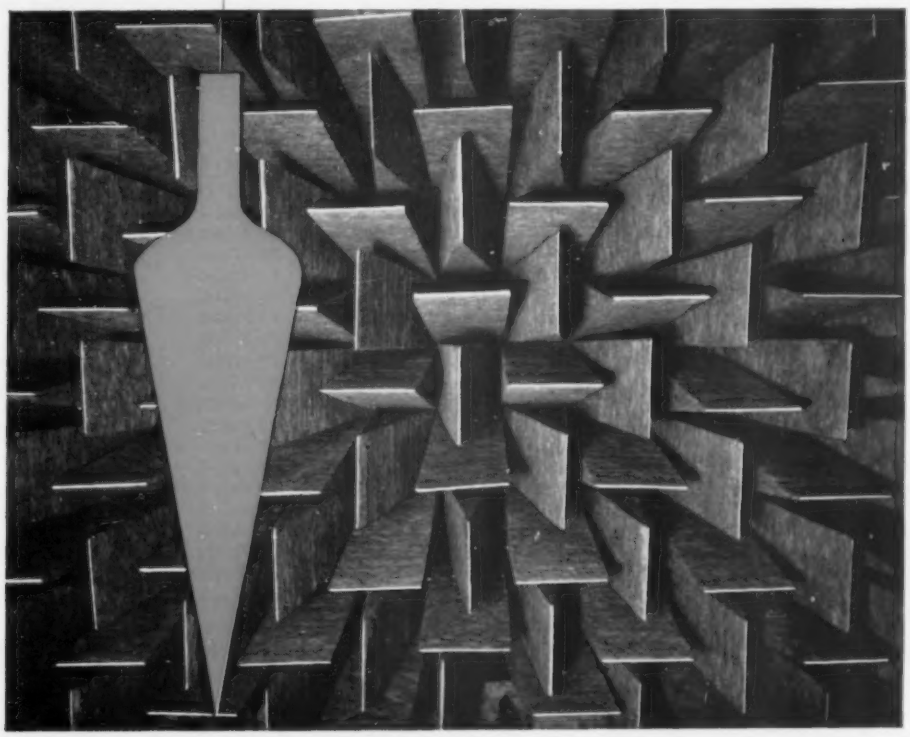
Northern Electric Research and Development Laboratories built a floating anechoic chamber. Although the appearance of this room is weird, its purpose is perfection; for here, there are no echoes, reflections or vibrations to distort the accuracy measurements of sound waves. ■ Wedges of Fiberglas, five feet long, project towards the middle of the room from all six surfaces, so that the equipment under test is completely surrounded by a mass of sound absorbent material. ■ This anechoic chamber is being used to test microphones, speakers, telephone transmitters and receivers, intercom systems and other communications equipment. ■ The chamber is an important new asset, but it represents just a fraction of the total facilities and personnel dedicated to the quest for progress in communications at the Research and Development Laboratories of Northern Electric Company Limited.

■ RESEARCH AND DEVELOPMENT LABORATORIES



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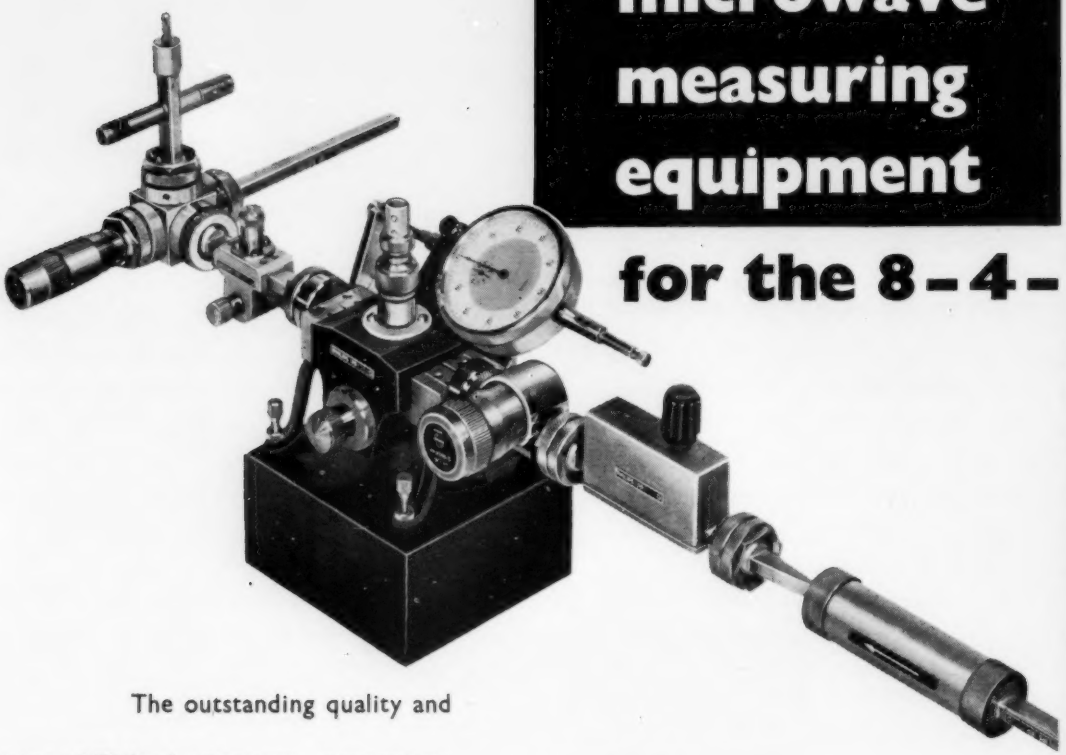
microwave measuring equipment for the 8-4-



The outstanding quality and precision of Philips' microwave components for the 8, 4 and 2 mm bands are in accordance with the high standards set by advanced research. The range of components is continuously being extended.

8 mm band (31—36 kMc/s)

PP 4420Q	ferrite isolator
PP 4382Q	standing wave detector
PP 4300Q	broadband wavemeter
PP 4270Q	sliding screw tuner
PP 4260Q	calibrated short circuit
PP 4222Q	adjustable crystal mount
PP 4200Q	klystron mount
PP 4170Q	matched load
PP 4150Q	rotary attenuator
PP 4130Q	flap attenuator
PP 4090Q	directional coupler
PP 4080Q	horn
PP 4050Q	hybrid Tee
PP 4035Q	twist
PP 4030Q	H-plane bend
PP 4025Q	E-plane bend
PP 4020Q	straight waveguide sections
PP 4020Q/AR	adaptor to flange UG599/U
PP 4020Q/BR	adaptor to flange UG381/U

4 mm band (60—90 kMc/s)

PP 4422E	ferrite isolator
PP 4300E	wavemeter

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Philips Electronics Industries Ltd.,
116 Vanderhoof Ave., Toronto 17, Ont. - Montreal: 8525 Decarie Blvd.

2 mm bands

PP 4270E	sliding screw tuner
PP 4260E	adjustable short circuit
PP 4220E	crystal mount
PP 4200E	klystron mount
PP 4170E	matched load
PP 4130E	flap attenuator
PP 4080E	horn
PP 4050E	hybrid Tee
PP 4035E	twist
PP 4034E	H-plane bend 180°
PP 4030E	H-plane bend 90°
PP 4025E	E-plane bend 90°

2 mm band (110—170 kMc/s)

PP 4400B	calibrated variable impedance
PP 4270B	tuner
PP 4260B	adjustable short circuit
PP 4230B	harmonic generator 4 mm → 2mm
PP 4220B	crystal mount
PP 4170B	matched load
PP 4080B	horn
PP 4050B	hybrid Tee
PP 4015E	clamping ring for claw flange
PP 4010E	claw flange

For the 2 and 4 mm microwave components Philips Research Laboratories have developed a waveguide coupling which fully satisfies the special requirements of this frequency range.

The Claw Flange offers amongst other advantages very small reflections ($|R| < 0.005$), compact construction of the microwave component and universal and simple fixing.

instruments: **quality *tools* for industry and research**

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Compact— 50 rectifiers on a printed circuit board 2¼" x 2¾"
New Sarkes Tarzian Silicon Rectifiers
Doubler socket
Half-wave socket

Sockets from Fastex Division, Illinois Tool Works

for plug-in sockets and printed circuits

This new series of silicon rectifiers is especially suited for use in printed circuit assemblies, or can be plugged directly into special sockets to facilitate assembly and servicing. Insulated case —11/32" x 3/16" x 1/4" high—eliminates many mounting problems. Leads are on 7/32" centers.

Reliability is excellent—in part because the construction minimizes axial strain on the junction. Special Tarzian oversize junctions increase inrush current protection, contribute to low voltage loss, and lengthen useful life in this as in other Tarzian silicon devices. Prices are realistic.

Complete line catalog available. Application engineering assistance is also available without obligation. Send for data sheet.

Tarzian Type	Amps DC (85°C)	PIV	Maximum RMS Volts	Maximum Recurrent Peak	Amps Surge (4MS)
12	.75	200	140	7.5	75
14	.75	400	280	7.5	75
16	.75	600	420	7.5	75

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IF YOUR RELAYS MUST

SWITCH UP TO 100 TIMES PER SECOND

HAVE A LIFE IN EXCESS OF A BILLION CYCLES

BE COMPLETELY RELIABLE AND FREE FROM CONTACT BOUNCE

THEN SPECIFY P&B MERCURY WETTED CONTACT RELAYS

An unusual combination of advantages found only in mercury-wetted relays has led many design engineers to specify them for tough switching jobs. Here are but 3 typical characteristics of our JM series:

RELIABILITY. Sealed-in-glass mercury contacts are renewed with every operation. Won't pit or weld. Make or break is positive . . . every time. No bounce, no chatter. Signals ranging from a few micro amps to 5 amps are switched with singular consistency.

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SPEED. Operate time is just less than 3 milliseconds using 2 watts of power. Release time is about 3.2 milliseconds. Thus, relays can be driven 100 times per second.

If your project calls for exceptional relay performance, perhaps the answer lies in our JM Mercury-Wetted contact relay.

JM SERIES ENGINEERING DATA

Contact Rating:
5 amperes maximum
500 volt maximum
250 volt-amp max. with required contact protection.

Contact Configuration:
Each capsule SPDT. Combination of capsules in one enclosure can form DPDT, 3PDT, 4PDT. (All Form D.)

Terminals:
Plug-in or hook solder; 8, 11, 14, or 20-pin headers.

Coil Resistance:
2 to 58,000 ohms.

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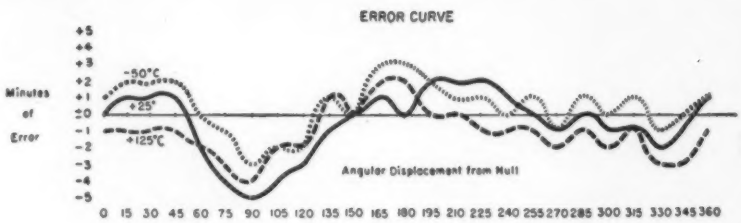
This Canadian-made SYNCHRO offers temperature stability plus lightness

This Size 8 Daystrom synchro provides temperature stability without increasing weight.

The encapsulated stator windings permit these units to be operated under severe environmental conditions. And, of greatest importance, in random sampling of Daystrom Size 8 synchros, error shift from room temperature has not exceeded 2 minutes over the entire temperature range of −55C to +125C.

Daystrom Size 8 "temperature stable" units are available as transmitters, differentials, control transformers and resolvers. Standard accuracy is ±7 minutes, but 5-minute units are also available on special order.



Data sheets and prints on the "temperature stable" Size 8 synchro are available on request. And remember, too, Daystrom makes a complete line of precision rotating components.

For more information, call or write Daystrom Limited, 1480 Dundas Highway E., Cooksville, Ontario; 5430 Ferrier Street, Montreal 9, Quebec. A subsidiary of Daystrom, Incorporated.

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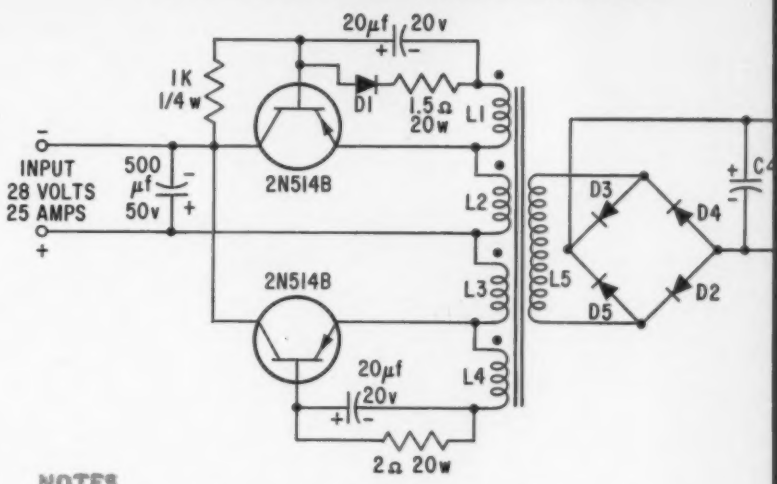

NOTES

L5 may be wound according to the output voltage desired, allowing about 0.639 turns per volt. The wire size should be large enough to allow one circular mil per millampere. The output current and load will then determine D2, D3, D4, D5, and C4.

L2, L3—17 turns each #10 bifilar wound

L1, L2—4 turns each #16

Core-type 50022-2A Magnetics, Inc.

Q1, Q2—2N514B 80 volt 25 amp each mounted on a minimum of 200 sq. in. of ¼" aluminum for operation up to 50°C.

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maximum ratings at 25°C

		2N511	2N511A	2N511B	2N512	2N512A	2N512B	2N513	2N513A	2N513B	2N514	2N514A	2N514B	unit
V_{CBO}	Collector-to-Base Voltage ($I_C = -5ma$, $I_E = 0$)	−40	−60	−80	−40	−60	−80	−40	−60	−80	−40	−60	−80	v
V_{CEX}	Collector-to-Emitter Voltage ($V_{BE} = +0.2$ v, $I_C = -5ma$)	−40	−60	−80	−40	−60	−80	−40	−60	−80	−40	−60	−80	v
V_{EBO}	Emitter-to-Base Voltage ($I_E = -5ma$, $I_C = 0$)	←	−30	→	←	−30	→	←	−30	→	←	−30	→	v
I_C	DC Collector Current	←	−10	→	←	−15	→	←	−20	→	←	−25	→	a
I_E	DC Emitter Current	←	10	→	←	15	→	←	20	→	←	25	→	a
I_B	Base Current	←					−5			→				a
	Total Dissipation	←					80			→				w
T_J	Junction Temperature	←					95			→				°C

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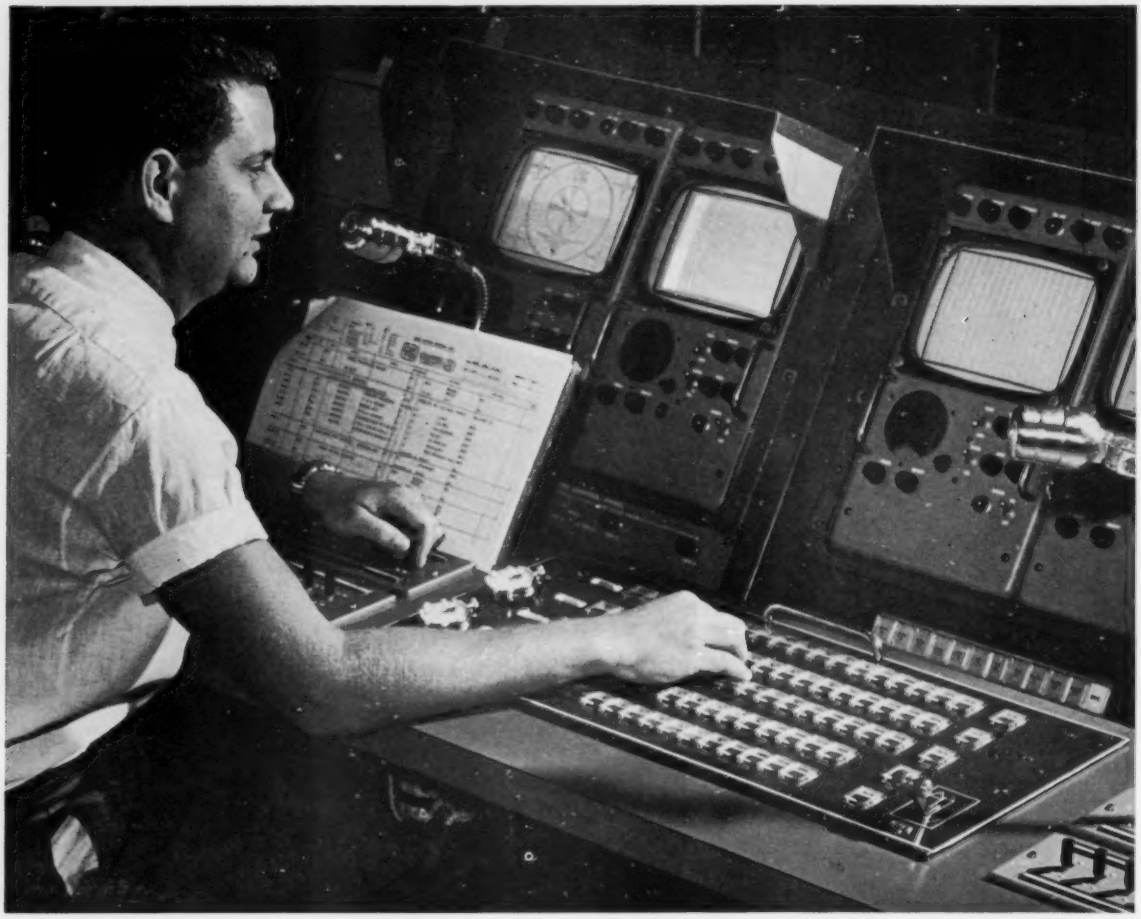

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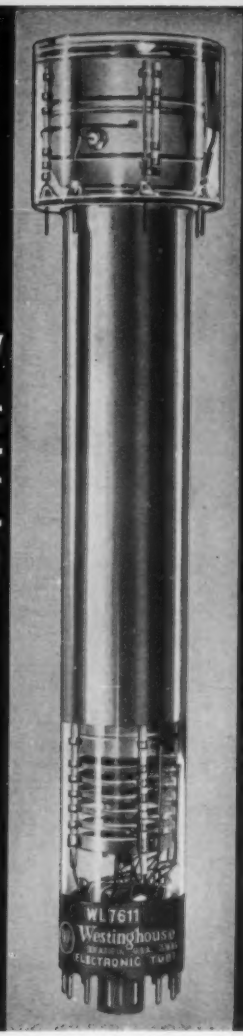

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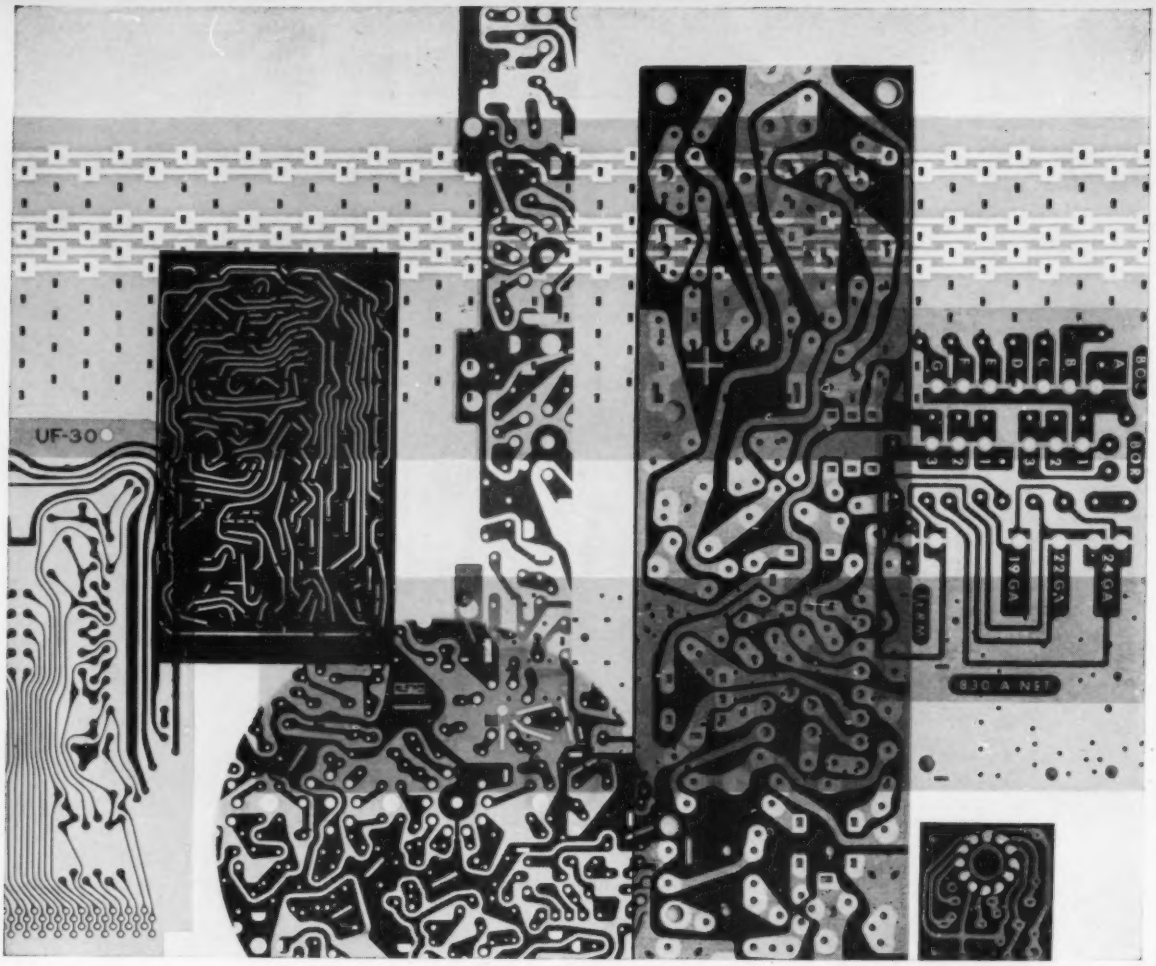

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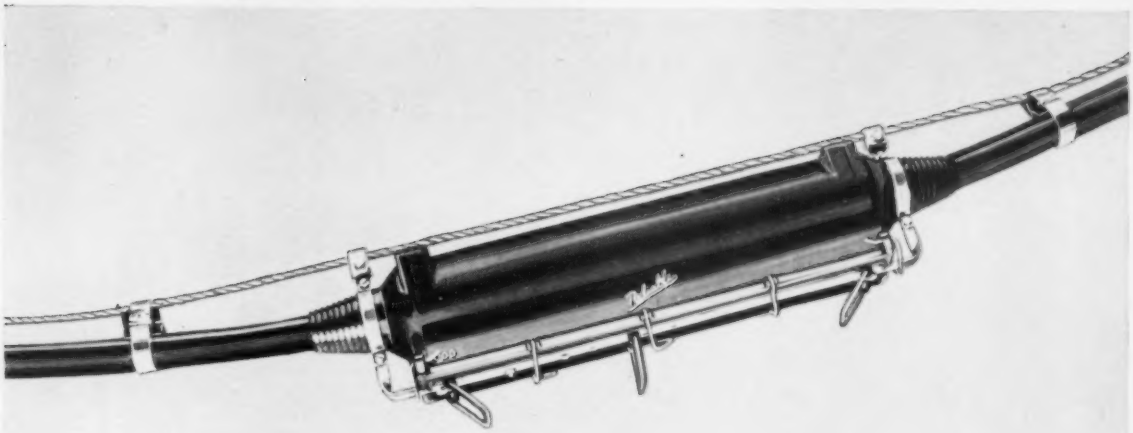

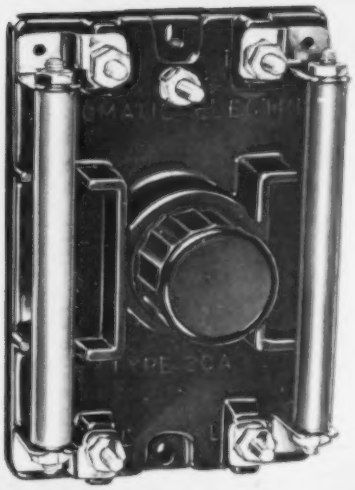

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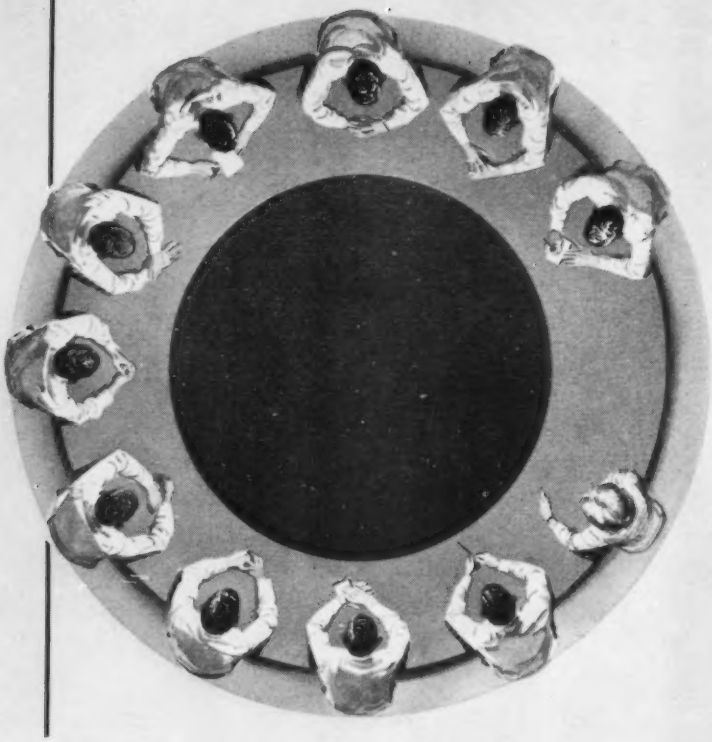

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Directorate of industrial research will promote development in Canada

John Lewis Orr
Director of Industrial Research

Mr. Orr was born in Toronto in 1916 and received his BASc degree in engineering physics from the University of Toronto in 1939. He then spent a year in various aircraft design offices in the United Kingdom, including the de Havilland Aircraft Co. and Supermarine Aviation Works.

He returned to Canada and joined the staff of the National Research Council in 1940. Six years later, he became Head of the newly-established Low Temperature Laboratory in the National Aeronautical Establishment. His employment was interrupted briefly while he attended California Institute of Technology where he obtained an MS degree in Aeronautical Engineering.

For his wartime research in the field of aircraft de-icing, Mr. Orr was awarded the M.B.E. During 1945, he was a member of the Canadian Enemy Science Investigation team in Germany and in 1949, attended the United Nations Scientific Conference at New York as a Canadian delegate.

From 1952 to 1955, Mr. Orr was seconded to the Aircraft Branch of the Department of Defence Production as a senior production officer. In 1955 he joined the Chief Scientist's Branch of the Defence Research Board as Director of Engineering Research. In addition to his normal duties, Mr. Orr is a national delegate to the Advisory Group on Aeronautical Research and Development (NATO), the Commonwealth Advisory Committee, Aeronautical Research Council and various Tripartite Technical Committees.

Mr. Orr is a Fellow of the Canadian Aeronautical Institute, Associate Fellow of the Royal Aeronautical Society, and a Member of the Aeronautical Sciences (U. S. A.).

Canadian industry received encouraging news from the Government recently. Increased funds will be made available for research on military projects to be carried out in industry.

The Hon. Douglas S. Harkness, Minister of National Defence, first referred to the new program during a speech in the House of Commons, Sept. 12.

"In the development of new equipment and new techniques we must work closely with Canadian industry as a whole. Awareness of this has led the government to authorize the Defence Research Board to develop an extended program of defence research in industry with a primary view of building up and maintaining a more adequate level of defence research capacity. The Department of Defence Production will be co-operating with the Defence Research Board in selecting the research objectives for this expanded defence industrial research program."

The program will aim at speeding the introduction of new technological advances into the design of military equipment. Canadian industrial organizations should then be in a better position to participate in the Defence Development and Production Sharing Program already established between the United States and Canada.

A Directorate of Industrial Research is being established at DRB headquarters to implement this program. Heading it will be John L. Orr, MBE, who will also retain his present responsibilities as Director of Engineering Research.

Objectives of the Directorate will be to encourage industry to strengthen its research and development capabilities by sponsoring applied research in the fields of defence interest. It is expected that industry will advance new ideas leading to research projects in support of which the Government would be prepared to make a substantial financial contribution. Thus it is hoped to stimulate a major expansion of industrial research activity generally, as well as a significant increase in the limited number of research groups presently active in Canadian defence industry.

Emphasis will be placed on the long-term aspects of defence problems and research efforts will be concentrated in selected fields in order to achieve the required level of technological competence. The program will be closely co-ordinated with the research activities of DRB laboratories, and fundamental research supported at Canadian universities under the DRB extramural grants system.

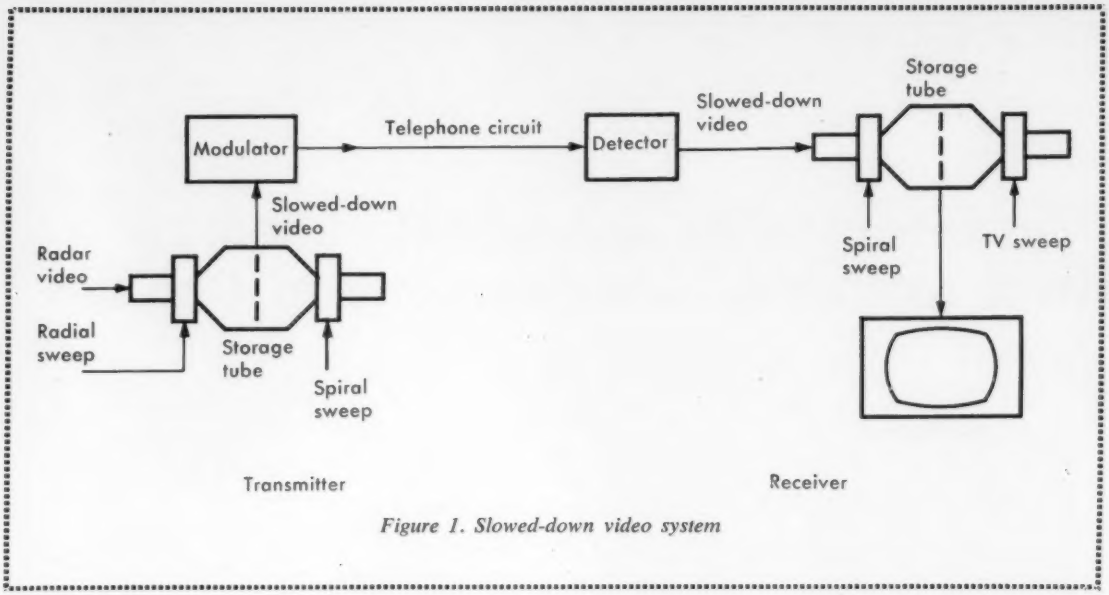

Figure 1. Slowed-down video system

Slowed down video permits transmission of radar pictures over telephone lines

T. W. R. EAST, SEN. MEM. IRE M. M. FEILCHENFELD, MEM. IRE*

Video signals from an air traffic control radar are converted into a signal of less than 1.5 kc bandwidth in a dual-gun storage tube. By modulation on an audio carrier, the signal is transmitted through a telephone circuit of wirephoto quality. At the receiving end, the signal is detected and written into another storage tube. TV readout is used to display the results on TV monitors.

At an air traffic control centre, there is a need for information about aircraft in the next air traffic control region, which may be beyond the reach of the local radar. This need could be filled by transmitting the radar picture from the distant air traffic control centre by some transmission medium. A typical path would be from Ottawa to Montreal (100 miles) or from London, Ontario to Toronto (120 miles). Video signals from a radar have a bandwidth of about one megacycle, and microwave links for transmitting this type of signal are expensive. The signal can be converted into TV form by a radar-to-TV scan converter and transmitted on a regular TV microwave link. But this, though readily available, is also expensive. The equipment described here uses normal telephone lines or telephone channels with a bandwidth of about 3 kc, for which the rates are less expensive.

To reduce the bandwidth of the raw radar video by a factor of about 300, it is possible to take advantage of the large redundancy of radar signals and code them suitably. The air traffic controller wants to know the range and azimuth of the aircraft relative to the radar and, because of the finite beam width of the antenna, he cannot know this more accurately than about 1 deg. He is not interested in the range to an accuracy of better than 1% or so. This means that the target can be in only one of 360x100 range-azimuth "boxes". As long as he is kept up to date every minute or less, it is not necessary to keep transmitting the exact position of the aircraft every antenna rotation. Thus ideally it is possible to store the contents of the "boxes" and report on them once per minute at the rate of 360x100/60 boxes per second or 600 times per second, and send the resulting signal through a telephone line. A realistic figure for the number of elements per second which can be transmitted in an economical telephone circuit is 2,000, leaving something in hand for the performance of the coding equipment.

One method for coding the signal is to use a radar-to-TV scan converter in which the radar information is written into a dual-gun storage tube in PPI fashion but the read beam executes a square raster quite slowly. Because the positions of targets are not quantized on to the raster lines but may occur between two lines, we allow 70% Kel factor. In one minute, 60x2,000 elements can be transmitted, so the number of lines in the raster will be about 400. The contribution to range uncertainty of the telephone line is therefore about 0.7%. (This calculation

*Raytheon Canada Ltd., Waterloo, Ont.

This paper was originally presented at the 1961 IRE Canadian Electronics Conference.

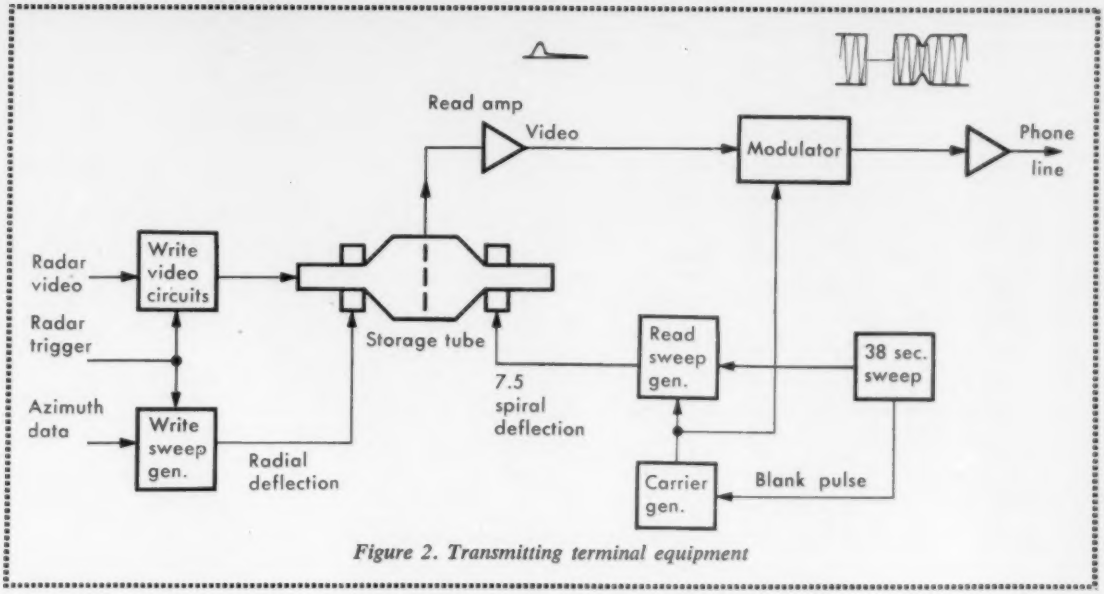

Figure 2. Transmitting terminal equipment

does not allow for retrace time on the raster and is in that respect too optimistic.)

Figure 1 shows in outline the equipment required at each end of the line.

Instead of a square raster we chose to use a more efficient method of scanning which covers only the circular PPI picture. The read beam moves in a spiral path at a constant angular velocity while its radial distance from the centre increases linearly with time. Thus the turns are equally spaced.

Since the targets form arcs whose angular extent depends on the beam width of the radar, they appear in the output as pulses of approximately constant width. The AASR air traffic control radar, for which this equipment is intended, has a beam width of 1.35 deg., and the spiral is scanned at 7.5 turns per second to give 2,000 elements per second. The frame time is reduced from one minute to 38 seconds, but even in this shorter time, 285 turns are put on, representing a range uncertainty of 0.5% instead of the former 0.7%.

Transmitting terminal

Figure 2 shows the terminal equipment at the transmitting end of the line.

The write side of the storage tube has conventional radar PPI deflection, which stores radar targets in their relative geographic positions on the storage screen. On the read side, the X and Y deflections consists of 2 sinusoids in quadrature, increasing linearly in amplitude for 38 seconds under the action of a very slow sweep generator. The sweep generator retraces in 2 seconds, and the spiral collapses to a point again. The spiral sweep is generated by dividing the frequency of an oven-controlled crystal source down to 15 cps in divider circuits, and using an Eccles-Jordan divider to obtain exactly symmetrical 7.5 cps square waves from the 15 cps. This square wave is carefully clipped between positive and negative 38-second sweep waveforms, and passed through a narrow-band filter tuned to 7.5 cps, which converts the linearly expanding square wave into a linearly expanding sinusoid. The filter response falls off at 6 db/octave and effectively suppresses the higher (odd) harmonics of 7.5 cps. Simple RC circuits give 45 deg lead and 45 deg. lag to the two outputs. The transient response of the filter and phase shift circuits introduces some distortion, but it is confined to the first two or three cycles of each sweep.

The crystal oscillator and divider chain also provide the carrier for transmission down the telephone line. The video output from the storage tube collector modulates the carrier negatively, so that targets decrease its amplitude to 50% of its normal value. During the two-second retrace, the carrier is shut off altogether. The carrier frequency is 2,160 cps, and the highest modulation frequency is about 1,000 cps, so that all the lower side-band and some of the upper side-band passes through the telephone line.

Early receiver design

A receiver circuit that was used in the earlier trials is shown in Fig. 3.

The received signal serves three functions. A detector extracts the video signal and turns on the write gun of the storage tube for each target. The sudden onset of carrier at the beginning of the 38-second sweep turns on a similar 38-second sweep generator in the receiver. The carrier frequency itself is used to provide exact information as to the rotation of the spiral, and synchronize the spirals at the transmitting and receiving ends. Thus the write beam at the receiver is performing the same manoeuvres as the read beam in the transmitter, and the target information is once more stored on a storage screen, this time in the receiver. Conventional TV sweep circuits make the read beam sweep the storage screen in a 525-line, 30-frame-per-second, interlaced raster, and the collector current consists of a TV signal containing the target information. When this signal is displayed on a TV monitor, it gives a bright display with the targets again in their relative geographic positions.

Transmission problems

It was recognized when the program was first conceived, that the telephone circuits available between the airports of major cities would not necessarily have level amplitude and delay response from 0 to 3,000 cps. The

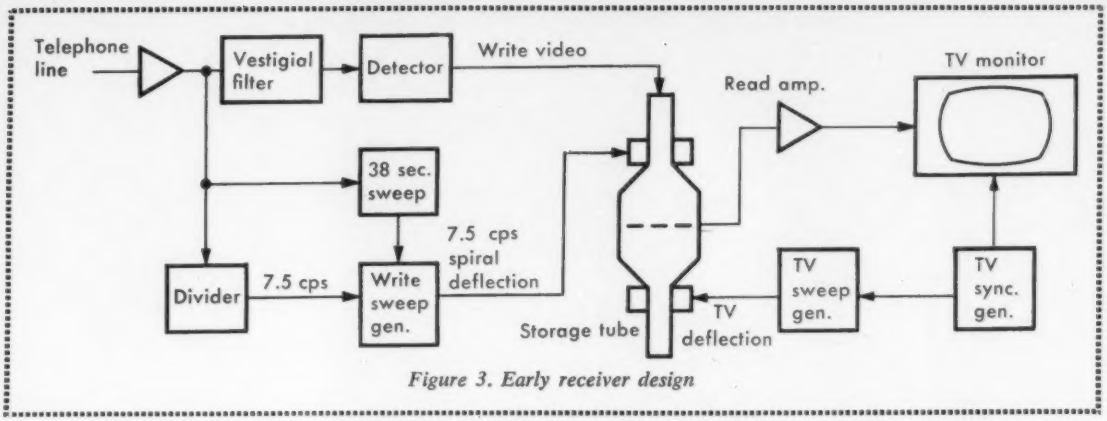

Figure 3. Early receiver design

Bell Telephone Company agreed to supply various circuits of various lengths starting and ending at the Raytheon Canada laboratory in Waterloo, so that the effect of telephone circuit characteristics could be tested. All were, however, to satisfy the following conditions:

Loss from 500 to 2,700 cps within 3 db of loss at 2,160 cps;

Delay from 500 to 2,700 cps within ±250 usec of delay at 2,160 cps.

All the telephone circuits except one met this specification. In the one case, we made measurements before the telephone company had completed their own setting up procedure, and finding that the delay was 300 usec at 600 cps, we requested the line should be left like that to give the equipment a more severe test than it received from the other circuits. No noticeable degradation occurred, even on this line.

Telephone circuits often carry an AGC device which inserts or removes loss in one or two db steps if the line loss varies due to natural causes. In accordance with wirephoto practice, the AGC units were disabled. Group level regulation by pilot channels, as used in frequency division multiplex systems for toll circuits, cause no problem.

It has to be remembered that by far the largest customer by volume of the telephone companies is still the man in the street using the circuits for conversation. All aspects of the telephone system are primarily engineered for this purpose and, although special services are provided for other kinds of customer and features such as delay equalizers installed and maintained, fundamental changes in the nature of the plant to suit an unusual requirement cannot be expected.

Experience with the lines, and reading of the literature revealed the following features which required modification of the Slowed-Down Video equipment design.

1. One of the circuits which ran for 40 miles above ground, showed a loss which changed by several db over a quarter of an hour when the sun came out and changed the temperature of the line. Since it would not be satisfactory to re-install the step type AGC system, an AGC circuit was installed in the receiver. This has to control the amplitude of the received carrier while ignoring the temporary decrease in strength caused by the modulation and the 2-second suppression for synchronization. It has a charge time constant of a few seconds and a discharge time constant of a few minutes and controls the suppressor of a 6AS6 tube in the signal channel. The AGC is arranged to start at maximum gain when the equipment is first switched on.

2. The frequency of a signal coming out from a carrier system is not necessarily equal to the frequency of a signal going in, because the carrier generator at the receiving terminal is not locked to the carrier generator at the transmitting terminal on some systems, and the signal may, for example, be translated upward by 96,000 cps and then downward by 95,998 cps. On some systems, the over-all frequency shift can be as much as 20 cps; it does not cause serious degradation of speech. Its effect on the Slowed-Down Video system, however, is to make the frequency of the spiral at the receiver different from that of the spiral at the transmitter, and the picture becomes twisted. If azimuth errors are not to exceed 1 deg. from this cause, the frequency shift must not exceed 0.02 cps, and telephone companies are not prepared to comply with this. For this reason, it is not possible to synchronize the spiral sweep at the receiving end by using the carrier of 2,160 cps as a synchronizing signal. It is necessary to use separate stable frequency generators at each end. A stability of one part in 10^5 gives 0.02 cps in 2,160 cps, and this stability is easily achieved with miniature oven-controlled crystals.

3. The first experiments on N-type carrier suffered from a very strange distortion of the signal after the two second sync. period. Instead of the carrier reaching full strength in a fraction of one cycle, it crept slowly up over several milli-seconds, so that the start of the spiral would have been quite indeterminate. This turned out to be caused by the use of compandors, which the telephone company removed at our request.

4. It soon became apparent why the compandors had been installed in the first place when random noise spikes, which were larger than 50% of the peak value of the signal, appeared, and triggered the receiver sweep circuits. The specification for the telephone circuit must call for impulsive noise to be at least 6 db below normal carrier level.

New receiver design

The receiver being used now is shown in Fig. 4. It incorporates features such as the AGC circuit to take care of the peculiarities of the transmission circuit.

The vestigial filter shapes the over-all response so that it has a level gain characteristic within 3 db from 500 to 2,450 cps. Detector distortion is negligible because the depth of modulation is not very great. As the vestigial filter removes part of the upper side band the over-all

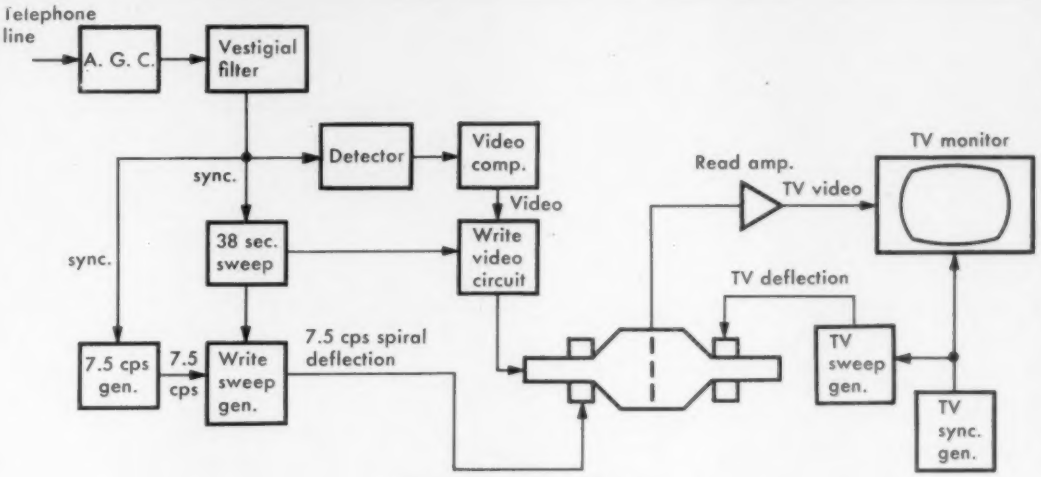

Figure 4. Final receiver design

video response from before the modulator to after the detector is 6 db higher from 0 to 350 cps than it is from 350 cps up. The video compensation network restores over-all video gain characteristic; the delay characteristic of the video compensator does not exactly match the resultant delay characteristic of the vestigial filter and detector, but the discrepancy does not produce appreciable distortion. The vestigial filter in the earlier design had a carefully shaped characteristic which was 6 db down at the carrier frequency and was skew symmetrical near it, but this filter was elaborate and its design laborious.

Operating trials will govern future design

In operation, a bright display is obtained which shows the tracks of aircraft picked up by the remote radar. The head of each track is extended every 40 seconds, and the tail slowly decays. The resolution and accuracy are mainly the resultant of the performance of the two scan converters at the transmitting and receiving terminals; the transmission path introduces very little degradation of the signal. The requirements of the telephone circuit do not seem to be particularly severe, except that some existing types of line may not meet the requirements for noise level.

This equipment was designed and constructed in the Engineering Department of Raytheon Canada Ltd. It has been supplied to the Canadian Department of Transport for evaluation in their air traffic control centers. Practical experience with the system will show whether it is suitable for operational use as it stands, or whether some of the parameters need to be changed. The present frame rate can be increased by minor modifications to the design, provided the over-all data rate is not increased. Higher data rates would require telephone circuits of greater bandwidth and tighter delay specification. END

Symbol generator helps air traffic controllers identify and direct aircraft

The symbol generator described in this article won the award for the "best Canadian-designed new product exhibited at the 1961 IRE Canadian Electronics Conference." Principal designer was R. W. Dankwardt, Raytheon Canada Ltd., Waterloo, Ont.

Increasing volume and speed of air traffic makes it necessary to provide an aircraft controller with a complete radar picture of all aircraft in his area, and with a means for identification of these aircraft. Ratheon Canada Limited has developed for the Canadian Department of Transport a symbol generator to be used with bright display equipment. Scan converters in the latter equipment obtain radar information from air traffic control radars and present it to television monitors. Television-type alphanumeric symbols are produced in the symbol generator and are displayed simultaneously with the radar information for the purpose of target identification.

A block diagram of the generator is shown in Figure 1. The position of any symbol is controlled by a joystick. Direct voltages proportional to the horizontal and vertical displacements of a joystick pass to the delay generators. These produce horizontal and vertical triggers which are delayed in time relative to the television sync pulses used to synchronize the system. The delayed horizontal trigger positions the symbol along a TV line while the delayed vertical trigger selects the line in the TV raster on which the symbol first appears.

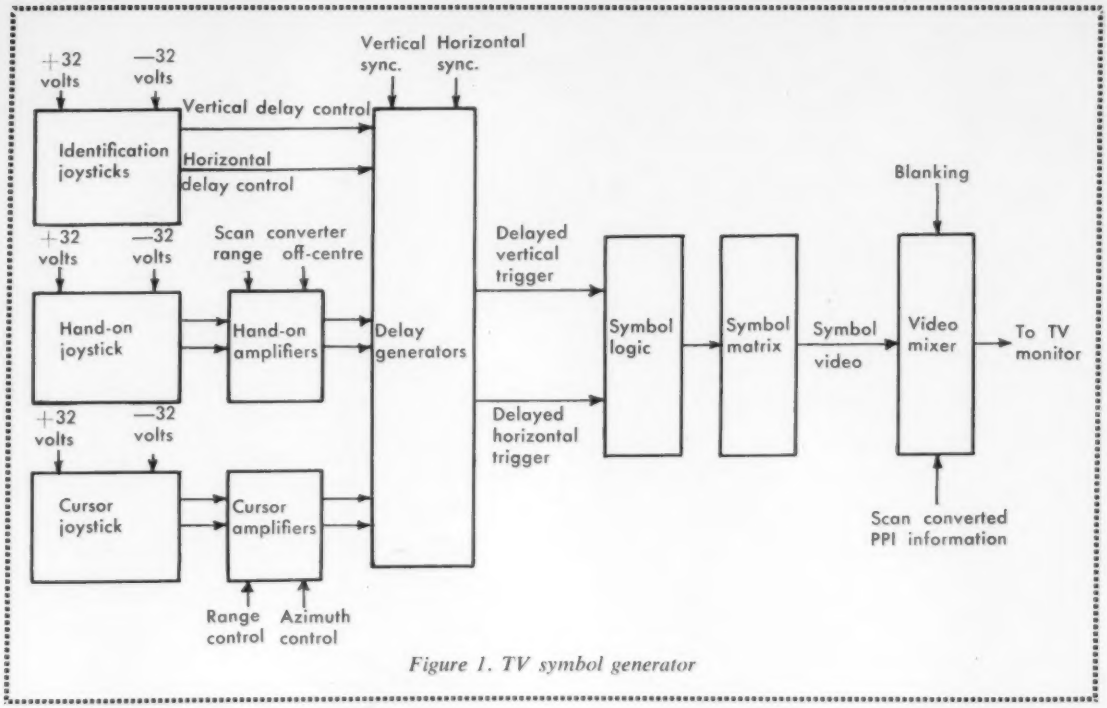

Figure 1. TV symbol generator

The delayed vertical trigger opens a gate permitting a three-stage binary counter to count off the seven TV lines on which the symbol is to be displayed. The output of the counter is decoded and these decoded outputs form one set of inputs to a symbol matrix.

The delayed horizontal trigger is shaped and amplified and used to drive a tapped delay line. The output from the delay line is a series of five pulses separated in time by intervals of 0.2 usec. These pulses form a second set of inputs to the symbol matrix.

Some, or all of these five very short pulses are transmitted on each of seven consecutive TV lines forming a symbol which is displayed on the TV monitor. The pattern is determined by a symbol matrix which is set to select dots which will make up the required letter or number. The matrix is a printed circuit board on which a number of diodes and resistors have been arranged to form a series of AND and OR gates.

A complete matrix would normally consist of 35 elements arranged in seven rows of five elements each. However, thirty-five elements is considerably greater than that required to generate a number or letter. In this system the symbols have been restricted to a maximum of 23 elements. The selection and positioning of particular elements to form an alpha-numeric is done with jumpers on the symbol matrix card. In the present system the symbol is written twice in each TV frame and the two fields of the frame are interlaced as in Fig. 2.

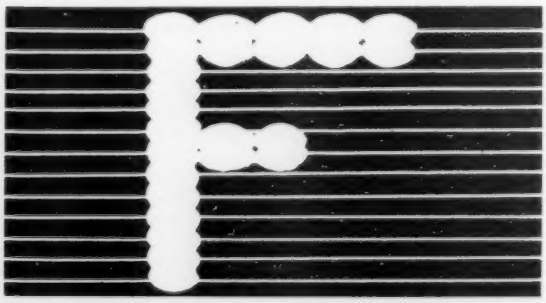

Fig. 2. A 5 x 7 symbol written twice each TV frame.

In addition to the identification facility, two other features have been incorporated in the equipment. The first of these is called Hand-On. Although the personnel at a given Air Traffic Control centre may all be using the same radar, the information on their displays will be obtained from several separate scan converters. For example, one of these scan converters may be off-centred to display traffic to the east of the airport while a second scan converter will display traffic to the west of the airport. Under these conditions, and assuming that a given target is visible simultaneously on both the east and the west sector displays, the target will appear at two different positions on the respective monitor screens. The hand-on feature positions an identification symbol against a target on an east sector display, for example, which is repeated on the west sector display so that responsibility may be transferred to the west sector operator with a minimum of ambiguity and conversation.

The second feature is a Cursor. Two symbols, a cross and a rectangle, are used to measure range and bearing. The cross can be placed over any point by means of a joystick. Calibrated range and azimuth controls are provided and these set the range and azimuth of the rectangle relative to the cross. If an operator wishes to direct an aircraft to a particular spot and to predict its time of arrival or assign a ground speed, he will set one symbol over the spot (visible as map signal) and the other over the target and he can then read range and bearing to the pilot. This feature will be useful for directing lost aircraft, or assisting pilots to avoid terrain or storms.

New approach simplifies the practical design of transistor amplifiers

H. L. ARMSTRONG*

This work is a continuation of some previous studies[1,2] aimed at simplifying the practical design of transistor amplifiers. In the present work, the variation with frequency of amplifier gain receives special attention.

It has been common to use the parameter beta, the short-circuit current gain in the common-emitter configuration, as the way of indicating the behaviour of a transistor. When dependence on frequency is to be taken into account, this has disadvantages. The beta usually is a strong function of frequency, decreasing rapidly with increasing frequency. It is awkward to work this in with the frequency-dependence of the passive circuit elements. Instead, it is advantageous to work with the transconductance, which is much less frequency-dependent and can, for many purposes, be taken to be constant[3,4]. Another advantage of this approach is that the method for designing transistor amplifiers closely resembles the method for vacuum-tube amplifiers. It appears that both kinds will be with us for quite a while[5]; anything that will avoid having to learn two separate design methods will make life easier for students and, indeed, for everyone concerned with the design of such amplifiers.

Parameters to be used

It is desired to use the parameters,

$$g_m = \partial I_c/\partial V_b \qquad \text{and}$$

$$Z_i = \partial V_b/\partial I_b$$

Of these symbols, I_c is the collector current, I_b is the base current, and V_b is the base voltage. Ordinarily, one is given:

$$\beta = I_c/I_b$$

Now,

$$\left.\begin{aligned} \frac{\partial I_b}{\partial V_b} &= \frac{1}{Z_i} \\ \frac{\partial I_c}{\partial I_b}\ \frac{\partial I_b}{\partial V_b} &= \frac{\partial I_c}{\partial V_b} = g_m \end{aligned}\right\} \quad \ldots\ldots (1)$$

When this is rearranged and interpreted it becomes

$$g_m = \frac{\beta}{Z_i} \quad \ldots\ldots\ldots\ldots (2)$$

β, of course, is the current gain, and Z_i is the input impedance to the base. Both of these quantities will be complex, in general. Now, to a good approximation, over the useful range of frequencies,

$$\beta = \frac{\beta_0}{1 + j\frac{f}{f_\beta}} \quad \ldots\ldots\ldots (3)$$

β_0 being the value at low frequencies, f the frequency, f_β the frequency at which $|\beta| = 0.707\,\beta_0$; and, of course, $j^2 = -1$. Also, to a good approximation,

$$Z_i = \frac{R_i}{1 + j\frac{f}{f_\beta}} \quad \ldots\ldots\ldots (4)$$

R_i being the input resistance at low frequencies. Thus

$$g_m = \frac{\beta_0}{R_i} \quad \ldots\ldots\ldots\ldots (5)$$

For a given transistor, β_0 and R_i will be known; thus g_m can easily be calculated.

One must also know the value of f_β. It is often not given; what is more often given is f_α. The relation is given by

$$\left.\begin{aligned} \beta &= \frac{\beta_0}{1 + j\frac{f}{f_\beta}} = \frac{\alpha}{1-\alpha} \\ &= \frac{\frac{\alpha_0}{1 + j\frac{f}{f_\alpha}}}{1 - \frac{\alpha_0}{1 + j\frac{f}{f_\alpha}}} = \frac{\alpha_0}{1 - \alpha_0 + j\frac{f}{f_\alpha}} = \frac{\frac{\alpha_0}{1-\alpha_0}}{1 + j\frac{f}{(1-\alpha_0)f_\alpha}} \end{aligned}\right\} \quad (6)$$

Thus

$$\beta_0 = \frac{\alpha_0}{1-\alpha_0} \quad \text{and} \quad f_\beta = (1-\alpha_0)f_\alpha = \frac{f_\alpha}{\beta_0 + 1} \quad . (7)$$

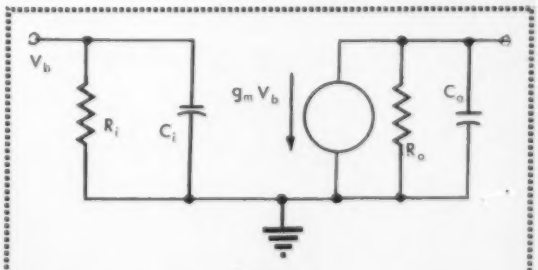

Figure 1

*Department of Physics, Queen's University, Kingston, Ontario.

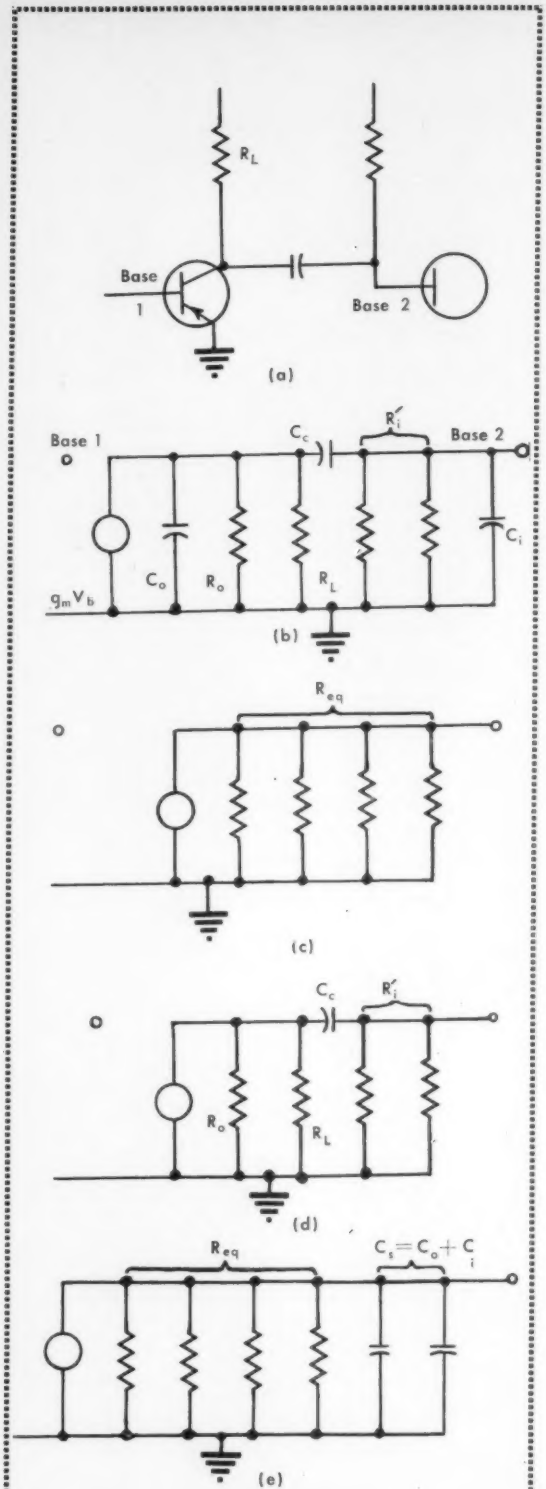

Figure 2

Thus the input impedance, in this approximation, is just that of a resistor R_i and a capacitor C_i in parallel, C_i being given by

$$C_i = \frac{1}{2\pi f_\beta R_i} \quad \ldots\ldots\ldots \quad (8)$$

The output impedance Z_0 (or output admittance Y_0) may also be needed; it is usually given in the form needed.

The representation here proposed, of course, may be interpreted in terms of an equivalent circuit, as shown in Fig. 1. It is to be noted that this is only an approximation. Collector to base feedback, for instance, has not been taken into account. However, the representation shown will often be adequate.

General comments on amplifier design

In the previous part, voltages and currents, being the total value at any electrode, were represented by upper case V and I. From now on, the concern will be with small signal, or "incremental" voltages and currents; they will be designated by lower case v and i.

The whole purpose of this work is to make the design parallel to that of amplifiers using vacuum-tubes. Accordingly, the reader will be referred to the method (and often to design curves etc.) in standard books, after it has been shown they are applicable. For the most part, the books used are Terman's "Radio Engineering," third edition, and "Radio Engineer's Handbook," first edition[6]. For brevity these will be referred to as (TR) and (TH), respectively, along with the number of the page, figure, table, equation, etc., to which reference is made.

Resistance-coupled amplifiers

The actual circuit is shown in Fig. 2(a), while Fig. 2(b), 2(c), 2(d) and 2(e) give the exact equivalent circuit, valid at middle, low, and high frequencies respectively. (Cf. TR, p. 230, Fig. 6-4.) (This circuit does not consider impedance in an emitter-bias arrangement, nor feedback in a collector-to-base bias arrangement; these will be considered later.)

It is apparent that at mid-frequencies the stage amplification A_M is:

$$A_M = g_m R_{eq} \quad \ldots\ldots\ldots \quad (8)$$

R_{eq} represents the equivalent value of the several parallel resistors shown in Fig. 2(c)

At high frequencies the gain A_H, is given by

$$\left|\frac{A_H}{A_M}\right| = \frac{1}{\sqrt{1 + \left(\frac{R_{eq}}{X_s}\right)^2}} \quad \ldots\ldots \quad (9)$$

Here $X_s = 1/2\pi f C_s$, and C_s is the total shunting capacitance, as shown in Fig. 2(e).

At low frequencies the amplification is A_L, and

$$\left|\frac{A_L}{A_M}\right| = \frac{1}{\sqrt{1 + \left(\frac{X_c}{R_F}\right)^2}} \quad \ldots\ldots \quad (10)$$

Here $X_c = 1/2\pi f C_c$, and C_c, as shown, is the capacitance of the coupling capacitor. Also R_F is given by

$$R_F = R_i' + \frac{R_0 R_L}{R_0 + R_L} \quad \ldots\ldots \quad (11)$$

These formulas are all completely analogous to the

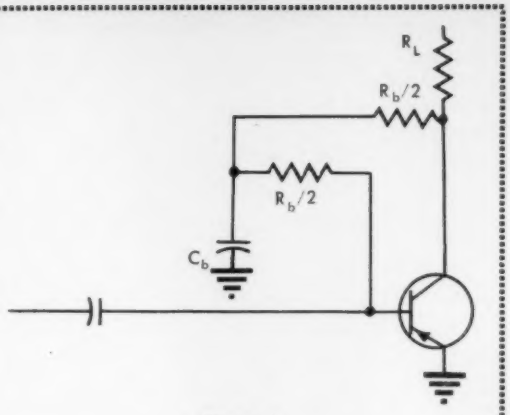

Figure 3

ones applying to a vacuum-tube stage. Thus, one may use information such as TR, p. 233, Table 6-1, and TR, p. 235, Fig. 6-8, and the associated methods, for transistor amplifiers just as well as for those using tubes.

Effects in emitter and feedback bias circuits

Consider the effect of an emitter-bias circuit first. As happens with cathode bias in a vacuum triode, the gain A is related to the gain A_∞ by:

$$\frac{A}{A_\infty} = \frac{1}{1 + g_m Z_e} \quad \ldots\ldots\ldots (12)$$

where A_∞ is the gain which would exist if the emitter bypass capacitor were of infinite capacitance. Z_e represents the impedance in the emitter circuit, i.e. of R_e and C_e at the frequency concerned. This again is just the same as the expression for a vacuum triode (or pentode with perfectly by-passed screen) and the design curves from TR, p. 239, Fig. 6-11 may be used.

Sometimes collector-to-base bias is used, as shown in Fig. 3, as a simple way of getting some compensation against the effects of temperature changes. At low frequencies, the by-pass capacitor C_b will be only partially effective, and there will be negative feedback. Again, when A is the amplification and A_∞ that for an infinite size of capacitor C_b, it may be shown that under certain approximations which will usually be valid

$$\frac{A}{A_\infty} = \frac{R_b}{R_b + Z_b} \quad \ldots\ldots\ldots (13)$$

Here Z_b is the impedance of a resistance of magnitude $g_m R_i R_L/2$ and a capacitance of magnitude $C_b R_b / g_m R_i R_L$ in parallel. It will be noticed that this is just the form for the effect of incomplete screen by-pass in a pentode (TR, pp. 236 and 237); thus the quantities such as Z_b can be calculated and the design curves of TR, p. 238, Fig. 6-10 used.

It would be possible to deal with a combination of emitter bias and collector bias; this would turn out to be analogous to a pentode in which both cathode and screen are incompletely by-passed. (TH, pp. 359-361.) However, this combination does not seem to be common enough to deserve inclusion here.

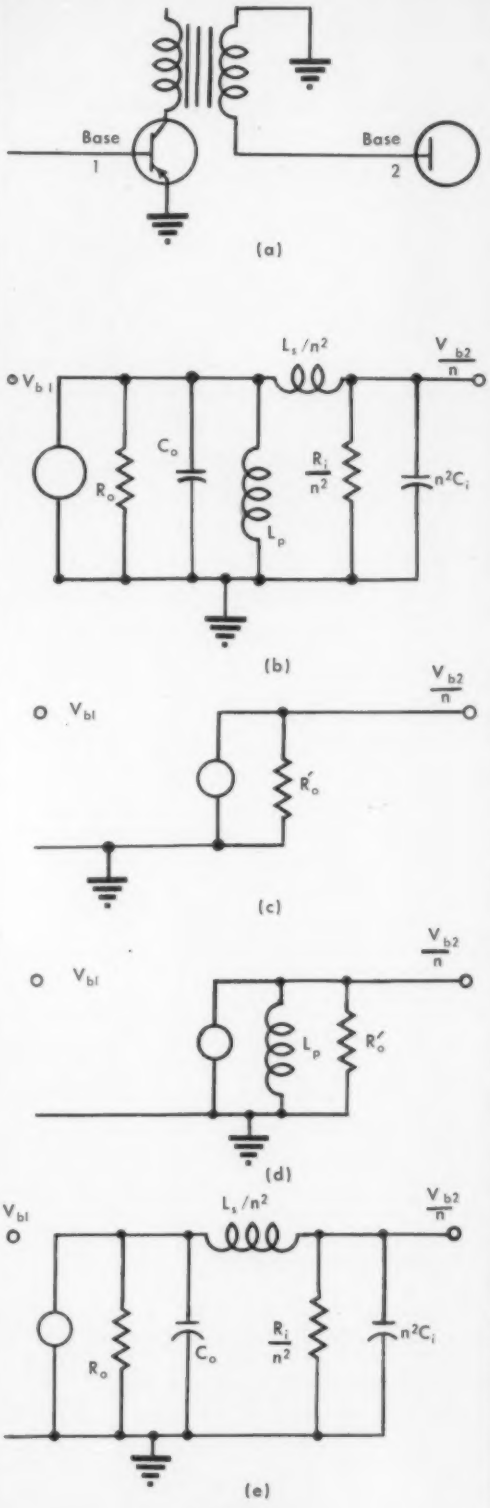

Figure 4

Transformer-coupled amplifiers

While transformer coupling is not used much with vacuum tubes nowadays, it is still moderately common with transistors.

The circuit is shown in Fig. 4(a), and the general equivalent circuit, and those applicable at medium, low, and high frequencies, in Figs. 4(b), (c), (d), and (e) respectively. At mid frequencies, as shown in Fig. 4(c), none of the reactive elements is of any importance, and the gain A is just

$$A = gm\, R_0' n \quad \ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Here n is the turns ratio of the transformer (ordinarily $n < 1$), and R_0' represents the parallel combination of

$$\frac{R_i}{n^2} + \frac{R_s}{n^2} \quad \text{and } R_0.$$

R_s is the resistance of the secondary winding. Ordinarily, one will match these so that

$$\frac{R_i}{n^2} + \frac{R_s}{n^2} = R_0$$

Note that often R_s can be neglected.

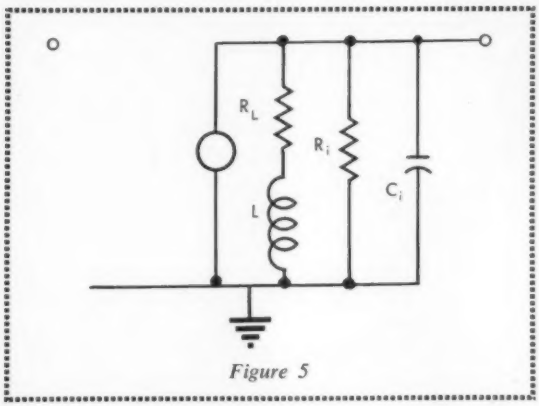

Figure 5

At low frequencies the leakage inductance L_p, of the secondary winding, must be taken into consideration, and the equivalent circuit is that shown in Fig. 4(d). Let the gain at low frequencies be called A_L; then

$$\left|\frac{A_L}{A}\right| = \frac{1}{\sqrt{1 + \left(\frac{R_0'}{\omega L_p}\right)^2}} \quad \ldots\ldots (15)$$

which is of the same form as for vacuum tubes, and thus published design curves (TR, p. 246, Fig. 6-14) may be used.

At high frequencies the equivalent circuit of Fig. 4(e) is applicable, and the gain, A_H, is given by a complicated function of frequency. Since the circuit with the transistor is more complicated than that with the tube, because of the input resistance, the curves given in the books will not work.

Any lengthy discussion would be rather academic, because, in building a circuit, one will probably be extremely limited in the transformers available. However, it is worth saying the following:

The similarity of the problem here to that of the high frequency response of the video amplifier, as discussed later, suggests that a similar treatment may be applied. In particular, the "maximally flat" response is useful, which makes the first and second derivatives, with respect to frequency, of the magnitude of the (high-frequency form of the) gain, vanish at low frequencies. It may be shown that the criterion for this is that

$$2\left(L_p + \frac{L_s}{n^2}\right)^2 C_i^2 R_i^2 = n^2\left(L_p + \frac{L_s}{n^2}\right)^2 + \left(R_0 + R_p + \frac{R_s}{n^2}\right) C_i^2 \quad \ldots (16)$$

In practice, knowing the total required gain, one will design enough stages, each with the gain at mid-frequencies given above, to meet the requirements. The behaviour at low frequencies can be investigated as proposed around Equation (15). It is ordinarily not feasible to design the transformer to satisfy any particular circuit; one can merely make the best of what may be available.

Video amplifiers

For transistors, as for tubes, there are many designs of video amplifier. Only the simplest, the circuit with shunt high-frequency compensation (peaking) will be considered here. Since the high-frequency compensation is the most difficult, and often the most important, it will be considered first. The equivalent circuit, shunt compensation included, is shown in Fig. 5.

The design curves given in the books for video amplifiers with tubes will not apply, since the situation is complicated by the input resistance of the transistor. Instead of trying to work out general cases, attention will be concentrated here on the "maximally flat" response, i.e., the case in which the compensating inductance is just large enough that the first and second derivatives, with respect to frequency, of the magnitude of the (high frequency form of the) gain vanish at low frequencies.

Let f_2 be the frequency at which the magnitude of the gain, without any compensating inductance, would be down to 0.707 times its value at low frequencies. It can be seen that

$$\left.\begin{aligned} \frac{1}{R_L} + \frac{1}{R_i} &= 2\pi f_2 C_i \quad \text{or} \\ R_L &= \frac{R_i f_\beta}{f_2 - f_\beta} \end{aligned}\right\} \quad \ldots (17)$$

Thus R_L is determined.

Now the inductance L must be chosen. It is easy to discuss the matter in terms of the quantity $Q_\beta = 2\pi f_\beta L/R_i$; a straightforward but long calculation shows that

$$Q_\beta = \frac{R_L^2}{R_i^2} \frac{\sqrt{2}\sqrt{1 + \frac{R_L}{R_i}} - 1}{1 + \frac{2R_L}{R_i}} = \frac{f_\beta^2}{f_2^2 - f_\beta^2}\left(\sqrt{\frac{2f_2}{f_2 - f_\beta}} - 1\right) \quad \ldots (18)$$

Usually, one will choose f_2, which will be about the highest frequency which it is desired to amplify. Then, f_β and R_i being known, R_L can be found, and hence the magnitude of the mid-frequency amplification. Since the total gain is known, this will show how many stages are needed. Then Q_β can be calculated, and thence L, to finish the design.

If the amplifier has many stages, it may be possible to improve its behaviour at high frequencies by making the inductance for some of the stages a little larger than that calculated above. The theory involved is quite complicated, but, by starting with the values calculated for "maximal flatness" and adding a little in places, one may often find by trial how to improve the circuit.

The actual value of load resistor chosen may be quite small; and, since there is no point in having the collector voltage excessively high, some additional resistance, bypassed by a capacitor, may be added in series. This is shown in Fig. 6.

At sufficiently low frequencies the bypassing will become ineffective, and the load resistance and thus the amplification will increase somewhat. This increase can be made at least partially to offset the decrease in gain caused by blocking capacitors, etc., and thus to improve the gain at low frequencies. This is done commonly with video amplifiers.

For video amplifiers the impedance into the base of the following transistor will usually be larger than that of the load resistor; under these circumstances the formula describing effects at low frequencies is essentially that given in R.T., p. 261 et. seq., and the curves given in TR, p. 263 may be applied to the design.

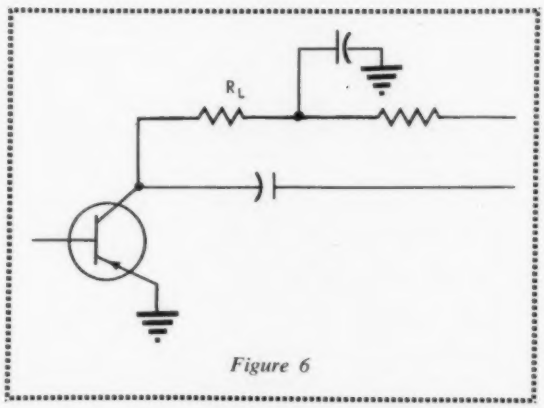

Figure 6

Although space does not permit any treatment even approaching completeness, the tuned amplifier, or narrow-band amplifier, of the sort used as intermediate-frequency amplifiers in radio receivers, should be at least considered. A common circuit is that shown in Fig. 7 One is interested especially in the behaviour near resonance, i.e., for angular frequencies near ω_0. This resonant frequency is given by

$$\omega_0 = \frac{\sqrt{R_i R_p}}{M} \quad \ldots\ldots\ldots \quad (19)$$

in the case in which the amount of coupling between the primary and secondary circuits in the coupling coil is such as to give maximum gain. M represents the mutual inductance between primary and secondary, and R_P is the "effective" series resitance in the primary coil, given approximately by

$$R_p = \frac{\omega_0^2 L^2}{R_0} \quad \ldots\ldots\ldots \quad (20)$$

L being the inductance of the whole primary coil (not just the part tapped).

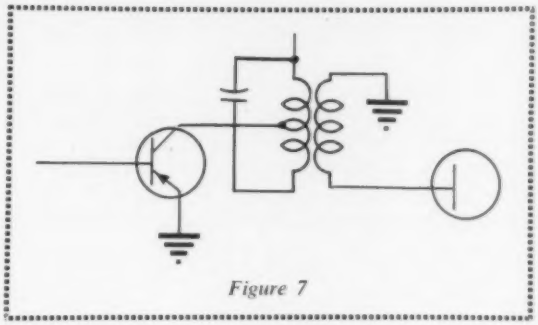

Figure 7

It may be shown, then, that

$$\text{Maximum Gain at Resonance} = -\frac{j g_m R_0^{3/2} \sqrt{R_i}}{2\omega_0 L} \quad (21)$$

and, for frequencies close to the resonant frequency

$$\frac{\text{Gain Off Resonance}}{\text{Gain At Resonance}} = \frac{1}{1 + j\frac{Q_0}{\omega_0}(\omega - \omega_0)} \quad \ldots\ldots \quad (22)$$

and here the designation is $Q_0 = \omega_0 L/R_p$. From this formula matters of bandwidth, etc., can be investigated as for any resonant circuit. For instance, the "six decibel bandwidth" for such an amplifier circuit is given by $2\omega_0/Q_0$. Enough has been said here to indicate how these circuits may be handled; any detailed treatment would require another article. END

(Professor Armstrong is nearing completion of a book on semiconductor devices. It will contain many of his views expressed in this and previous articles published in CEE. News of the book will be carried in "For your library" as soon as publication is completed.)

REFERENCES:

1. H. L. Armstrong, "How to design transistor amplifiers," Canadian Electronics Engineering, Vol. 3, No. 4, page 29, April, 1959.

2. H. L. Armstrong, "How to design transistor power amplifiers," Canadian Electronics Engineering, Vol. 3, No. 11, page 22, Nov., 1959.

3. H. L. Armstrong, "Proc. IRE, 46, 1949, 1958.

4. H. L. Armstrong, "Proc. IRE, 47, 83, 1959.

5. For a good, sober, discussion of this matter, cf. the paper presented by R. E. Moe, General Electric Co., at the 1960 Winter Meeting of AIEE.

6. These were published by McGraw-Hill Book Co. in 1947 and 1943 respectively.

The operation of linear diode detectors

J. K. PULFER, MEM. IRE*

The basic principles of operation of the "linear" detector are reviewed in an effort to clarify some of the confusing non-linearities in the multiple input case. The discussion is introduced by a review of the more important properties of signals and random functions of time.

The material presented in this report represents the result of reading and assimilating published literature on the so-called "linear" diode detector.

There are many properties of diode detectors which make the detected output a nonlinear function of the input, in particular when noise or a second signal is present.

To understand the behavior of a nonlinear device when noise is present, some familiarity with the statistical methods and terms used in handling random quantities is necessary.

TIME-VARYING QUANTITIES

We will distinguish between variables $E(t)$ which can be described as a function of time with a definite value at each instant of time, and variables $N(t)$ which are random functions of time, and cannot be specified at a given instant. The first type will be called signals, the second noise.

Seven properties of signals

(1) The time function $E(t)$ describes the signal.

(2) The time average of $E(t)$ over an interval T is:

$$E = \frac{1}{T}\int_0^T E(t)\,dt$$

(3) The average squared value is:

$$E^2 = \frac{1}{T}\int_0^T E(t)^2\,dt$$

(4) The frequency spectrum of the signal is:

$f(w)$ = Fourier transform of $E(t)$

$f(w)$ may be continuous or discrete depending on whether $E(t)$ is periodic or non-periodic in time.

(5) The power spectrum of the signal $F(w)$ defined so that the amount of power accepted by a bandpass filter over the range w_1 to w_2 would be given by:

$$P = \int_{w_1}^{w_2} F(w)\,dw$$

(6) The autocorrelation function of the signal, which is the Fourier transform of the power spectrum, can also be defined as the average power absorbed by a circuit element if the voltage across the element is $E(t)$ and the current through the element is $E(t+\tau)$

$$\text{i.e. } E(\tau) = \frac{1}{T}\int_{-\infty}^{\infty} E(t)\,E(t+\tau)\,dt$$

(7) The cross correlation between two signals is the power consumed by an imaginary element if the voltage across the element is $E_1(t)$ and the current through the element is $E_2(t)$.

Properties of noise

Three of the most important properties of random functions will be described in some detail, because of the usual lack of familiarity with these concepts. This will be followed by a general list of properties with their definitions.

The first important property of noise is its amplitude probability density function (APD). This function is independent of time and frequency. There is no one-one relationship between the frequency spectrum and the APD of a sample of noise. The function tells the probability, or expected percentage of time during which the instantaneous value of the noise voltage will lie between the values E and $E + dE$. The APD is important because from it may be calculated the average and the rms values of the noise. The average value obtained from the APD is called the ensemble average, and is equal to the time average for stationary time series (ones whose statistical properties are not functions of time).

A fairly simple example shows how the ensemble average is related to the probability density function.

Suppose that when throwing darts at a board, the probability of landing at a distance r from the centre of the board was proportional to the square of the distance from the centre. We wish to find the average distance out after a large number of trials. To do this, we will add up all the individual distances, and divide by the number of trials n. At a distance r_1, the probability will be kr_1^2 and so the number of darts at this distance would be nkr_1^2. So in the averaging process we would put r_1 down nkr_1^2 times, or just $r_1(nkr_1^2)$. Then summing over all values of r we would get

$$\text{average } r = \frac{1}{n}\int_0^{\infty} r(nkr^2)\,dr$$

$$= \int_0^{\infty} rP(r)\,dr$$

Or, in terms of the noise voltage,

$$\overline{E'} = \int_{-\infty}^{\infty} E\,P(E)\,dE$$

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The APD of the sum of two voltages is the convolution of the two APD's, that is to say, it is the inverse Fourier transform of the product of their transforms.

By far the most common APD function for random noises is the Gaussian or error distribution. Again, this does not imply any particular form of frequency distribution or amplitude vs time function, other than that the amplitudes of the individual frequency components be also random functions of time, or that there be a sufficiently large number of non-random components adding up to produce an approximately Gaussian distribution.

The second property is called the power spectrum of the noise. It is defined as a continuous function of frequency giving the noise power per unit bandwidth. The definition is identical with that for signals.

The frequency spectrum of the noise voltage in a receiver is of importance, because it allows the total noise power to be calculated.

$$P = \int_{-\infty}^{\infty} F(w)\, dw$$

Passage of noise through any four-terminal network with non-resistive or non-linear elements usually causes a change in the power spectrum.

The effect of a linear network on the spectrum can be calculated from the transfer function $G(w)$ of the network. A linear passive network can only narrow the spectrum and can only reduce the noise power. This, of course, neglects the noise generated in a resistive element, which would make the element active.

A non-linear network such as a power law device [output = (input)^2] can either increase or decrease the effective bandwidth of the noise. These points will be discussed further in the section on TRANSDUCERS.

The third most important property of a noise voltage is given by its autocorrelation function. This function is defined for noise exactly as it was for signals, and bears the same relationship to the power spectrum.

As an example, if the noise is pure white, then it is completely uncorrelated, and its autocorrelation function would be a delta function. On the other hand, if the frequency spectrum is an impulse, i.e., dc, then there would be complete correlation independent of correlation time.

Summarizing the above discussion, noises have the following properties.

(1) The amplitude probability density function $W_1(N_1)$ gives the probability that N will lie between N_1 and $N_1 + dN$.

(2) The ensemble average of $N(t)$ is

$$\overline{N} = \int_{-\infty}^{\infty} N\, W_1(N)\, dN$$

(3) The variance squared, or mean square value of $N(t)$ is

$$\overline{N}^2 = \int_{-\infty}^{\infty} (N - \overline{N})^2\, W_1(N)\, dN$$

where $(N - \overline{N})$ might be called the ac component of $N(t)$.

(4) The power spectrum of the noise $N(t)$ can be defined exactly as for signals.

(5) The autocorrelation function of $N(t)$ is the Fourier transform of the power spectrum.

(6) The cross correlation function of the two noises can be defined exactly as it was for signals.

Since in actual cases all signals and noises must have a beginning and end, none are truly stationary time series. However, as long as the above statistical properties are constant within a known error during the period of observation, they can be considered stationary.

Short time signals can be considered to have power spectra, etc., which are functions of time. The idea is not rigorous, but is valuable for describing the operation of some simple circuits.

It is also instructive to note that all actual signals have a random component due to circuit noise, and so can never be specified completely at a given instant. As the signal to noise ratio decreases, a point is reached (at about 10 db SNR) when the signal description becomes invalid, and the noise description is necessary.

TRANSDUCERS

General discussion

Circuit elements in general can be classed as linear or non-linear according to whether the characteristics of the elements vary with the applied voltages or currents.

Vacuum tubes as used in amplifiers can usually be considered linear if they are operated within their Class A or Class B ratings.

In general, a linear transducer is one which has an output $O(t)$ for a given input $I(t)$, and the relation $O(t) = f(t)\ I(t)$ holds independent of the magnitude of $I(t)$ over the operating range of the device.

The usual method of treating such a device is to write

$$o(w) = g(w)\ i(w)$$

where

$o(w)$ = Fourier transform of $O(t)$
$i(w)$ = " " " $I(t)$

and

$g(w)$ is the frequency response of the transducer.

A more general method would be to use complex frequency $s = \lambda + jw$ in which the transforms would be considered Laplace, and $g(s)$ would be the complex transfer function of the transducer.

For the case of noises, which cannot be expressed as functions of time, the use of power spectra, correlation functions and $g(w)$ is necessary, but otherwise the treatment is similar. A linear device would not increase the bandwidth associated with a sample of signal or noise.

The treatment of non-linear devices is much more complicated. If the characteristic of the transducer can be written as independent of time and frequency, as in a square law detector then $O(t)$ can be found for any $I(t)$ and similarly for any noise input, the output would be fairly easy to determine.

If the characteristic is not continuous but is independent of time and frequency, then several methods

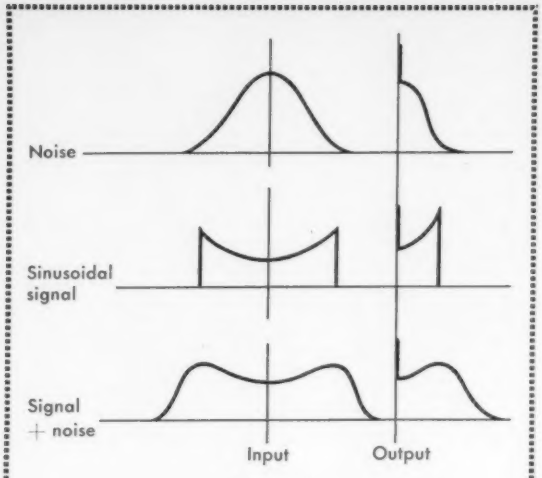


Figure 1

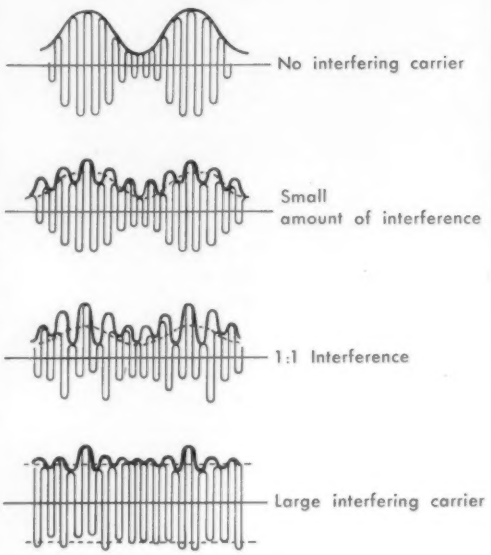


Figure 2

are available.

(1) The non-linear characteristic may be expressed in terms of a power series, and the above method used.

(2) For simple cases like the envelope detector, in which the output bears a simple relation to the input in spite of the non-linear circuitry involved, no difficulty is encountered.

(3) The integral representation of the characteristic method describes the discontinuous characteristic as a contour integral in the complex plane. It is applicable to continuous v^{th} law detectors, discontinuous v^{th} law, and biased v^{th} law. It has been discussed by Rice in Bell System Technical Journal, Vol. 24, 1945, pp. 149-150.[3]

(4) A Fourier analysis method was described in Communications and Electronics, published by AIEE, Jan. 1955.

Most of these methods can be applied to noises also, but the analysis is not easy. The method used usually depends on the type of signals and noise, and their relative amplitudes.

Diode detectors

A particular non-linear device which merits a detailed discussion because of its popularity as a circuit element is the "linear" diode detector with an RC load circuit.

This problem has never been completely treated, although many detailed studies have been made of its different aspects.

The description of the operation can be broken down into four general divisions, the criterion being the time constant of the RC load circuit relative to the carrier and modulating frequencies, and the noise bandwidth.

Let (1) R_1C be the discharge time constant of the detector load circuit
(2) R_0C be the charging time constant of the detector load circuit
(3) ω be the angular frequency of the signal carrier
(4) B_s be the bandwidth of the input signal
(5) B_n be the bandwidth of the noise input centred around the carrier frequency.

The four most important cases are then

I. $R_0C < R_1C << 1/\omega_0$

II. $\frac{1}{\omega_0} << R_0C < R_1C << 4\pi/B_s$

III. $\frac{1}{\omega_0} << R_0C < R_1C \gtrsim 4\pi/B_s$

IV. $\frac{1}{\omega_0} << \frac{4\pi}{B_s} << R_0C < R_1C$

It will be noticed that in each case $R_0 < R_1$. This insures that the condenser will charge to some dc value which will bias the rectifier, and this is by far the most common case. Increasing R_0 and decreasing R_1 would tend to decrease the output, and eventually revert to cases I and II but with low-pass post-detector filters.

CASE I—This case cannot usually be obtained with practical circuits, and a carrier frequency above 10 Mc, because the output capacity of the diode, along with the wiring capacities of the output circuit, is sufficient to cause some filtering of the carrier, and biasing of the rectifier.

Franz has investigated this case theoretically (see reference in Burgess, Phil. Mag., May, 1951).

The output would have an APD as shown in Fig. 1.

The output spectrum would consist of the input spectrum plus the spectrum of the envelope, plus harmonics of the input spectrum.

CASE II—The case II detector can only operate when the modulation frequencies are much less than the carrier frequency, and when the noise bandwidth is relatively narrow. This type is usually called the envelope detector, although perfect envelope detection is never possible. Theoretical results obtained using the ideal envelope detector agree quite well with experimental results.

Some of the more important properties of the envelope detector are as follows:

Output power spectrum

For a modulated carrier input, the output spectrum is that of the modulating voltage, with an additional dc component due to the carrier. The addition of noise causes slight distortion and reduction of the modulation with resultant broadening of the spectrum.

For noise input, the output spectrum is strongly dependent on the amount of carrier present. It would vary from a low pass duplicate of the input spectrum for large signal to noise ratios, to a spectrum occupying almost double the bandwidth with no carrier present. Modulation on the signal also broadens the noise spectrum. The explanation of this behavior will be discussed further under non-linear properties.

Output amplitude probability densities

For a modulated carrier input, the amplitude distribution function is that of the modulating voltage, with an additional dc component due to the carrier.

For noise input, as with the spectrum, the amplitude distribution is very strongly dependent on the amount of signal present. For very large carrier to noise ratios, the output amplitude density function is a replica of that of the input noise, which is essentially Gaussian for most practical cases. However, as the carrier is removed, the amplitude distribution function approaches that of the envelope of the input function. For a Gaussian narrow band noise input, the amplitude distribution function of the envelope is called the Raleigh distribution.

Non-linear effects of the envelope detector

(1) Discrimination in favor of the stronger of two carriers.

This phenomenon can occur in various degrees depending on the relations between the IF bandwidth, audio bandwidth, and the placement of the two carriers within this bandwidth.

The most important of these is the relation between the *RC* time constant of the detector and the time of one period of the frequency difference between the two carriers. The two carriers would combine to produce a resultant pulsating at the difference frequency. If the smaller of the two carriers is modulated, it will affect the waveshape of the total as shown in Fig. 2 for different signal strengths of the interfering carrier.

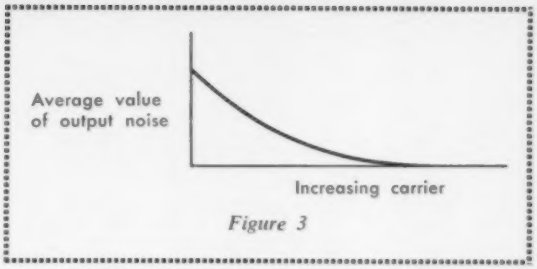


Figure 3

In each case the solid line shows the resultant envelope, whereas the dotted line shows the average of the envelope which is of the order of the modulating frequency of the interfering signal.

If *RC* were only small enough to follow the dotted curve and not the solid curve, then the modulation on the one carrier would be reduced by the presence of the other as can be seen from the diagrams. In effect, the detector would become a converter, and the modulation of the small signal would be superimposed on the difference frequency, instead of coming out as audio.

(2) For a mixture of signal and noise, the envelope detector would discriminate against the signal in favor of the noise.

For noise alone with no signal, the output would be the envelope of the input. For input noise with a Gaussian distribution, the envelope would have a Raleigh distribution as explained above.

With the addition of signal, the noise would become superimposed on the carrier, and so the envelope of the total would have the original Gaussian distribution for large carriers.

The Raleigh distribution is non-symmetrical and so would have a dc component. The Gaussian distribution is symmetrical, and so has no dc component.

As a result, the dc or average value of the noise can be plotted as a function of the input signal carrier strength as shown in Fig. 3.

With an ideal envelope detector, the output would be the average value of the noise plus the average value of the rectified signal. Thus total dc output

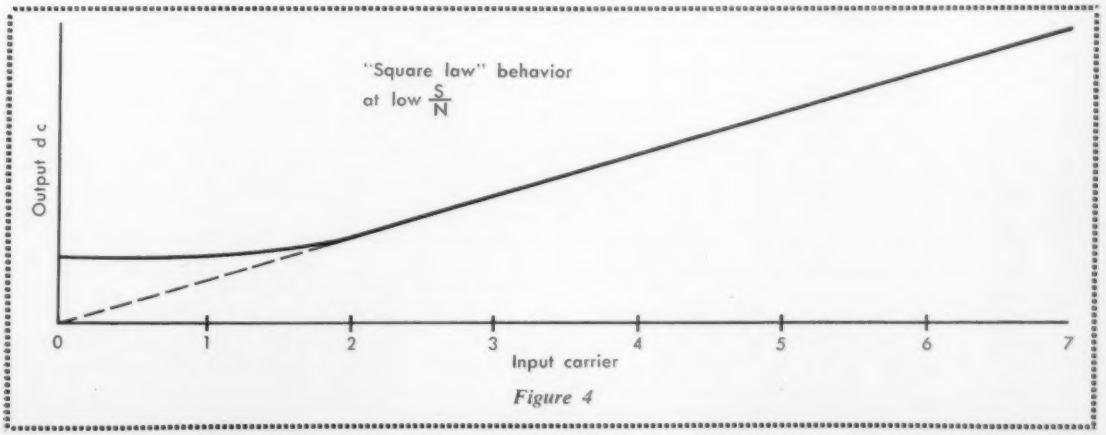


Figure 4

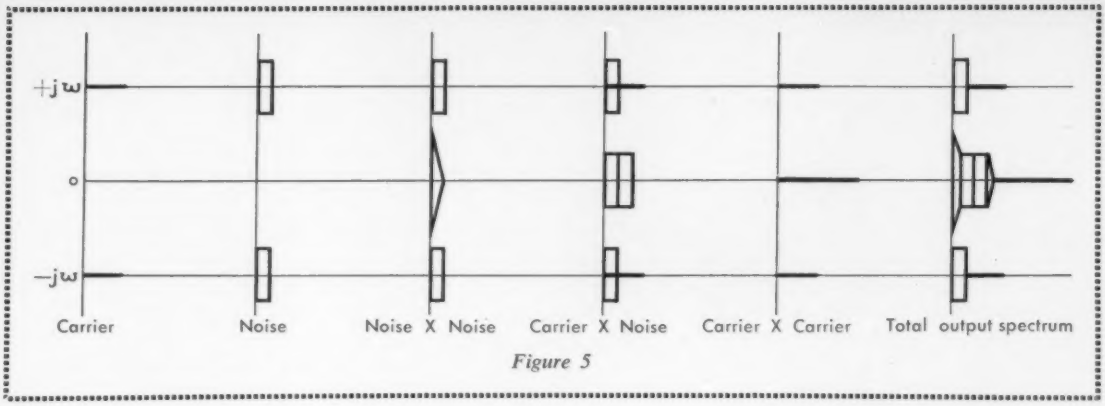


Figure 5

can be plotted against input carrier strength (Fig. 4), with the scales normalized so that input noise is considered unity.

This curve can be taken as the transfer characteristic of the detector, for purposes of obtaining output when the input consists of a modulated carrier plus noise. It can be seen immediately that the percentage modulation of a carrier would be reduced by the presence of noise when the signal to noise ratio is of the order of 1:1 or less. It can also be seen that distortion of the modulation will result, with attendant broadening of the audio signal spectrum.

Thus far we have considered only the effect of the input noise on the output signal. The input signal would also have an effect on the output noise, causing the spectrum of the output noise to vary with the carrier strength of the signal.

With respect to the spectra of the output noise, the envelope detector behaves much like a square law detector. This is to be expected since the linear characteristic of the diode can be written in the form of a power series, and so consists of a linear part, a square law part, etc.

The spectral distribution of the output noise from a square law detector can be obtained by the simple graphical method outlined below (suggested by E. L. R. Webb, National Research Council). The origin on a movable graph (on which are plotted spectra of one of the inputs), is superimposed on each of the frequency components of the other input (plotted on a fixed graph). Then mark off on the fixed graph the sections or points covered by the components of the movable graph, adding up all superimposed components. This sums up all the possible products at any given frequency, as shown in Fig. 5.

As explained above, the linear detector behaves very much like the square law detector with regard to output spectral distribution, and it can be shown that

(a) the noise spectrum from a linear detector at audio frequencies is a copy of the input noise spectrum for large signal to noise ratios,

(b) the output noise spectrum spreads out to almost double the bandwidth of the input noise spectrum when all signal carriers are removed.

It will follow from an inspection of the above diagrams, that modulation of the signal carrier will cause an additional widening of the output noise spectrum.

It can be observed that since the output noise consists of the input beating with itself, plus the input noise beating with the input carrier and sidebands, noise power is increased in passing through the detector, so that the detector again discriminates in favor of the noise. (Note—A true envelope detector must have power gain.)

The semi-envelope detector

The third case where the time constant of the detector is of the order of the audio frequencies involved, is believed to be at least as common in practical use as the envelope detector.

Since the bandwidth of the noise envelope with no signal is equal to the full IF bandwidth, the value of R_1C required to give true envelope detection would be of the order of one-half of that required to pass the signal modulation without distortion.

Some work on the analysis of a semi-envelope detector has been done by R. A. Johnson,[6] but no detailed theoretical results are available.

Some of the properties of the semi-envelope detector are as follows:

Output power spectra

For a modulated c.w. signal input, the rise time of the output signal is governed by R_0C and the decay time by R_1C when the rise and decay times of the signal are shorter than these values.

The resulting distortion of the modulation tends to broaden the spectrum.

For noise input, unless the time constants of the detector load circuit are fast enough to allow the passage of a band the full width of the IF noise, negative peak clipping will occur in excessive amounts, with a resultant broadening of the output noise spectrum.

Amplitude distribution functions

Because the detector will not produce a true envelope output, the amplitude distribution functions will be different for the clipping detector, and will again depend on the signal to noise ratio, so that the detector will behave in a non-linear manner.

Non-linear effects

(1) Discrimination in favor of noise.

Since the noise would not be completely passed by this type of detector, the RC time constant in the load would charge up to some dc value higher than the average value of the Raleigh distribution of the envelope. As a result, with no carrier present, the output would look as in Fig. 6.

If an unmodulated carrier were added to the input noise, an additional dc component would appear in the output, causing the condenser to charge to a higher point, and therefore discharge through a greater voltage range in a given noise cycle. As a result, the addition of a carrier has the following effects:

(a) Increase the dc output.

(b) Increase the peak to peak value of the ac output noise components.

(c) Decrease the dc component in the output due to the noise.

(d) Increase the number of high frequency components of the noise passed by the detector.

A plot of the output dc component versus carrier input (Fig. 7) shows the same non-linear effect as for the envelope detector, but increased due to the additional effect of the clipping as described above.

As a result, the detector again discriminates in favor of noise at low input signal to noise ratios.

(2) Discrimination in favor of a strong signal.

When two signals are applied to a non-envelope detector, the modulation of the smaller signal is reduced, provided that the beat frequency is too large to be passed by the RC load circuit, for the same reason as for the envelope detector.

However, an additional effect would be present due to the fact that an increase in the interfering carrier would also tend to increase the ac component of the beat frequency and decrease the variations in its average value, i.e., the modulation of the smaller carrier. Thus the RC load of the detector would cause an increase in the non-linear action.

Numerical facts about the class III detector which have been determined by R. A. Johnson[6] are:

(a) For no clipping, the instantaneous envelope must be such that

$$-\frac{dE}{dt} < E/R_1C$$

(i) For a carrier with m% modulated sine wave envelope,

$$\frac{R_1C\omega m}{(1-m^2)^{1/2}} < 1 \text{ for no clipping}$$

(ii) For noise, the probability of clipping is finite for any finite C. For an IF pass band composed of two tuned circuits,

$$R_1C\omega < 3/4 \text{ for } P < 0.1$$

where the noise bandwidth is $2\omega/\pi$.

(b) For a linear detector with a resistance load (by experiment),

(i) The correlation function of the output noise would be essentially independent of the percentage modulation of the applied signal.

(ii) The total low frequency output power would be independent of the frequency spectrum of the input noise.

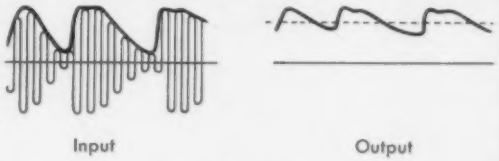


Figure 6

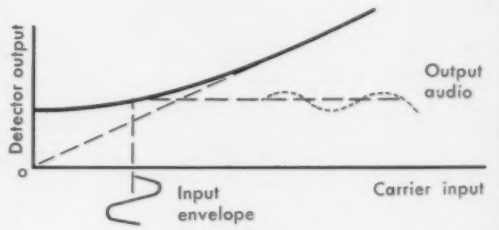


Figure 7

Voltmeter case

This is the case of the diode detector with a load circuit time constant very long with respect to one cycle of the lowest modulation frequency. This case has been analyzed in detail by Burgess (Phil. Mag., May, 1951) and he has also treated the case where the detector has a square law and an exponential characteristic.

Some of the characteristics of this type of detector are:

(a) The output is essentially dc and so the amplitude distribution functions and the power spectra are not important properties of the output.

(b) For a signal input, the dc out may be anything from zero to the peak of the modulation, depending on the ratio of R_1 to R_0.

(c) For a noise input, the output dc level may be made to increase indefinitely, limited only by the peak saturation of the source supplying the detector. Thus, with proper R_0/R_1, the detector can be made to read rms for a Gaussian distributed input. END

BIBLIOGRAPHY

A more detailed study of the non-linear action of detectors can be obtained from the references listed below.

1. Fubini and Johnson, "Signal-to-noise Ratio in AM Receivers," Proc. IRE, Vol. 36, No. 12, December 1948, pp. 1461-67.

2. Bennett, W. R., "Response of the Linear Rectifier to Signal and Noise," Bell Syst. Tech. J., Vol. 23, 1944, p. 97.

3. Rice, S. O., "Mathematical Analysis of Random Noise," Bell Syst. Tech. J., Vol. 23, 1944, p. 202 and Vol. 24, 1945, p. 46.

4. Busignies and Dishal, "Some Relations Between Speed of Indication, Bandwidth and Signal-to-random-noise Ratio in Radio Navigation and Direction Finding," Proc. IRE, Vol. 37, No. 5, May 1949, pp. 478-88.

5. Middleton, David, "Rectification of a Sinusoidally Modulated Carrier in the Presence of Noise," Proc. IRE, Vol. 36, No. 12, December 1948, pp. 1467-77.

6. Johnson, R. A., "The Rectification of Signals and Random Noise by a Linear Detector," Tech. Rpt. No. 145, Cruft Labs., Harvard, May 1952.

7. Jackson, Willis, "Symposium on Applications of Communications Theory," London, Butterworth, 1953.

8. Smith, R. A., "The Relative Advantages of Coherent and Incoherent Detectors; A Study of their output Noise Spectra under Various Conditions," Proc. IEE, Institution Monograph, Aug. 15, 1951, Monograph No. 6, Radio Section.

E. Palin, past chairman, greets Students Branch members brought to the conference as guests of IRE Canadian Region.

IRE Canadian Electronics Conference reflects industry upsurge in 1961

The 1961 IRE Canadian Electronics Conference brought into public view much of the significant work which has taken place in the industry during recent months.

Despite the heavy competition from imports in certain areas, and despite the difficulties experienced 2 to 4 years ago through loss of military markets, the industry is in a reasonably healthy state today.

The decision to hold the Canadian conference every second year appears to have been wise. In any event, this year's meeting was well attended by technical people, and well supported by exhibiting companies.

Attendance reached an all-time high of 9,637 engineers and business people. In addition, a number of school groups attended the conference. By comparison, technical attendance was 7,720 in 1959, 9,122 in 1958, 7,647 in 1957, and 7,818 in 1956.

Exhibit space this year was at a premium; 31% more space was taken this year than in 1959. Over 185 Canadian, United States and overseas companies displayed their products and services.

Technical sessions were well attended, with some having standing room only. Particularly successful were the tutorial sessions on Plasma Physics, and Millimeter and Submillimeter Waves.

The final two sessions of the conference were panel sessions on Education, and Import and Export Problems. The latter panel, organized by members of the Electronic Industries Association of Canada, reviewed the events and activities of EIA pertaining to Canada's import problems. As in previous recent EIA meetings, the major concern centred around imports from Japan.

Dealing with the export side of the discussion, W. S. Kendall, chairman of the Electronics Division of EIA, pointed out that Canadian industry could not expect to be in a favorable position to export goods unless it developed original products. He commended the government for instituting a program of promoting defense research in industry (see page 35 for further details).

"The government must be commended for this constructive step," said Mr. Kendall, "and we hope the concept can be extended further to non-military markets and to cover broader segments of industry."

Design awards

A highlight of the conference was presentation of awards for the best Canadian-designed new product, and the best Canadian-designed new component exhibited at the conference.

Raytheon Canada Ltd. was honored for its development of a symbols generator used in air traffic control. When accepting the award for the company, Dr. T. W. R. East said, "This award will be a great encouragement to everyone in our engineering department at Waterloo, in our work on air traffic control equipment, and especially to R. W. Dankwardt who was principal designer of the symbol generator, M. M. Feilchenfeld, who was principal designer of the slowed-down video system, and W. J. Grey, who supervised the construction of both equipments. (For complete details see the paper on page 36).

Ferritronics Ltd., Willowdale, Ontario, was honored for its LC network type filters for 455 kc FM communications. These filters are being so well accepted in the U.S. market that Ferritronics is preparing to manufacture them at a new plant in Buffalo, N.Y.

The next Canadian Electronics Conference will be held in Toronto in October of 1963. Heading it as general chairman will be L. C. Simmonds.

L. C. Simmonds, right, has been elected general chairman of the 1963 IRE Canadian Electronics Conference. Wishing him success is F. J. Heath, general chairman for 1961.

This Mercury space capsule attracted a great deal of attention. It was exhibited by the Canadian Astronautical Society in co-operation with NASA.

H. Ross Smyth, chairman of the awards committee, presents a plaque to G. Armitage (L), B. Tennent and W. O. Akkerman of Ferritronics Ltd. for the best Canadian component exhibited — an IF filter.

Group in Tektronix booth was typical of visitor interest.

Many new developments were exhibited at the convention. G. Woolnough of the Northern Electric Research Labs demonstrated a planar PNP transistor.

Electronic Industries Association organized a panel session on imports. Discussing problems were EIA members W. H. Jeffrey (L), J. R. Dunn (moderator) and W. S. Kendall.

Scientists in government agencies such as the National Research Council and the Defence Research Board frequently invent circuits or devices having commercial application. In such cases, patents are taken out and made available in industry. Persons interested in obtaining licenses should contact Canadian Patents and Development Ltd., 100 Sussex Street, Ottawa 2, Ontario.

Function resolver

Case No. 2735

Inventors: N. F. Moody and P. M. Thompson

This invention was made at the Defence Research Telecommunications Establishment, Ottawa, where it has been incorporated into an airborne navigation computer. The use of the resolver in this application is described more fully in the paper "A Lightweight and Self-Contained Airborne Navigational System," Proc. IRE, May, 1959. This invention is patented in the United States. Patents have been applied for in Canada and the United Kingdom.

This invention provides a digital function generator which can represent continuously both linear and nonlinear functions of an angle, and can be adapted to operate as a function resolver.

The generator is like previous ones insofar as it produces pulses by interrupting the path between a light source and a photocell with a rotating sectored disc or drum. Unlike previous types, however, it can generate functions of either positive or negative sign, and for angles from zero to 360 deg. An additional property of the invention is that it will generate a function of two variables, or generate more than one function simultaneously.

The rotating disc or drum has information tracks consisting, for example, of transparent marks or apertures in opaque material. The sides of these marks generate pulses which, when accumulated in a bi-directional counter, provide the digital output. One track is linear, having a constant number of marks for every degree around the disc or drum. A second is a sign track, to indicate whether the device accumulating pulses should be adding or subtracting. A third is sinusoidal, with the number of pulses generated proportional to the sine of the angle of rotation. (Cosine functions are obtained from another pair of photocells mounted, at right-angles to the existing pair, on the sine and sign tracks). A moveable photocell is used, either in conjunction with the sign track or its own reference track, to gate the counter so that it only counts over an angle determined by the setting of the photocell.

Figure 1 shows a block diagram of a function generator according to this invention. For every revolution of the disc or drum the counter accumulates a digital representation of the sine of the appropriate angle.

The invention may be used as a resolver if the shaft of the rotating element is made to turn a number of times in proportion to an input while the output pulses are summed. The resulting sum will represent the product of the input and the angular function being generated. Such a resolver is illustrated in Figure 2. Input pulses are summed in a counter, from the score of which the linear track output is subtracted to provide the error signal for the servo system. The tachometer generator is used in the usual way to damp the servo system. A similar circuit, using a cosine output from the function generator, will provide cosine resolution.

By reversing the roles of sine or cosine and the linear outputs in the circuit of Figure 2, either cosecant or secant functions may be resolved. Tangent and cotangent may be obtained by using sine and cosine outputs in a similar way. END

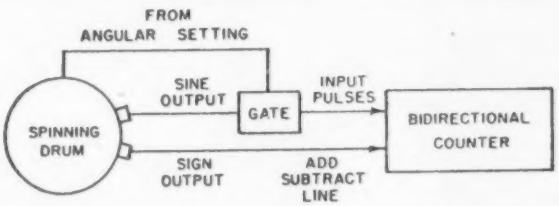


Fig. 1. Spinning drum device used as a sine function generator.

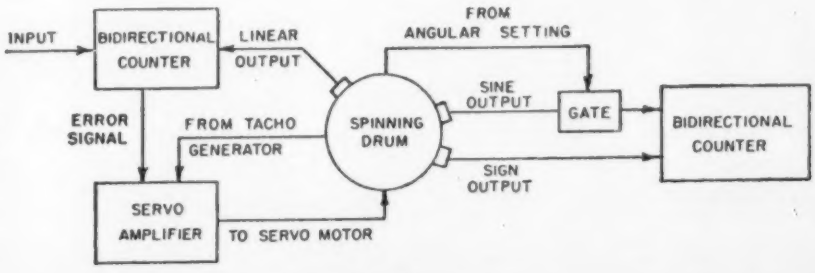


Fig. 2. Spinning drum device used as a digital sine resolver.

Canadian firm expands facilities for rebuilding picture tubes

From a small beginning in 1955, Industrionics (Canada) Ltd., Windsor, Ont., has developed into a major manufacturer of replacement TV picture tubes.

Starting with four employees in an 8,000 sq. ft. plant, the company had sales of $64,000 in its first full year of operation. Annual sales have since climbed as high as $260,000 with an attendant increase in staff to 19 and plant size to 14,000 sq. ft.

Now, the company, which was formerly known as Winco Electronics Co. Ltd., is going to the public for financing which will enable it to expand considerably in Canada and the United States.

Winco Electronics, Inc., was set up recently in Detroit to duplicate the Canadian manufacture of picture tubes for the U. S. market (formerly served by the Windsor plant).

Industrionics, Inc., established in 1959, is probably the only successful producer of remanufactured ignitron tubes, using an internally developed process.

W. Wayne Shapiro, president of Industrionics (Canada) Ltd., has been with the firm almost from its inception. He graduated from the University of Michigan in 1943 with a BSc degree in metallurgical engineering, and was immediately appointed to the university's engineering research staff. A year later he entered the U. S. Marine Corps and was assigned to radar research at the Naval Research Laboratory in Washington. Upon discharge he became chief engineer of a Detroit firm performing production electroplating for the automotive industry, and in 1948 formed his own TV service company in Detroit. He joined Industrionics (Canada) in 1955.

Both of these companies are wholly owned subsidiaries of the Canadian firm.

Market is $10 million annually

How many remanufactured picture tubes does the Canadian public buy in a year? Mr. Shapiro estimates it spends $10 million a year to buy approximately 250,000 remanufactured tubes.

"We currently produce about 3,000 tubes a month, but this includes production for the U. S. market," said Mr. Shapiro.

The U. S. market has proved so promising that the company recently set up a subsidiary organization, Winco Electronics, Inc., in Detroit to serve it. Completely new equipment has been installed and production has just started.

"We expect to start with 500 remanufactured picture tubes per week in Detroit," Mr. Shapiro announced. "Anticipated sales to one major electronics jobber alone may reach $300,000 during the first year's operation there," he announced.

This marks the second time that the Canadian company has expanded its operations into the U. S. An earlier venture, Industronics Inc., was established in Detroit in 1959.

This firm remanufactures ignitron tubes for resistance welding equipment which is used by heavy steel fabricating companies such as automobile, appliance and aircraft manufacturers.

"To our knowledge, we are the only company to successfully produce and market remanufactured ignitron tubes," said Mr. Shapiro, who developed the process his company is using.

There are three basic sizes of ignitron tubes—designated B, C and D—used in resistance welding equipment, and the company remanufactures all three. Their tubes sell for approximately half the price of new ignitrons, with a warranty which is equal to new.

Sales of $12,000 in the first full year of operation increased to $41,000 in the second year ended March 31, 1961, and are expected to more than double in the current fiscal year.

"We are already selling to many major automobile manufacturers, as well as appliance and aircraft producers, but we have not even scratched the surface of the potential," said Mr. Shapiro, who estimates the U. S. market alone at $5 million annually.

Expansion of the ignitron tube plant and establishment of the television tube plant in Detroit are part of an extensive corporate expansion plan for which the parent Industrionics (Canada) is now seeking public financing.

Diversification is one objective

Near the top of the list of plans for the group of companies is a project to establish a research and development section for additional and allied electronic products.

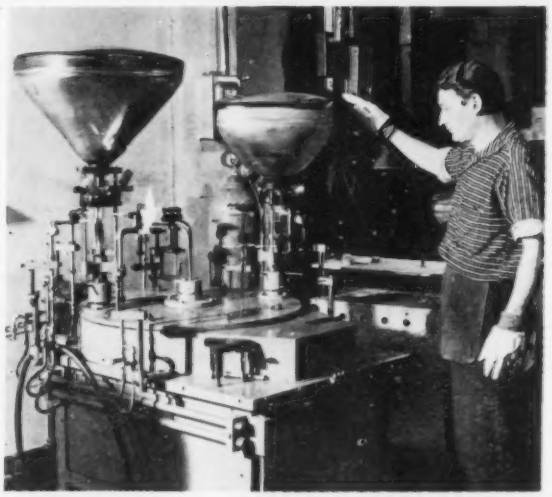
A new product already slated for Canadian production in the immediate future is a portable TV circuit analyzer such as is used by all television schools and service organizations.

Another market which promises to develop in future is the remanufacturing of color television picture tubes. The equipment at both the Canadian and U. S. picture tube plants can be adapted for this. ▸

This is how TV picture tubes are rebuilt at Industrionics

1. First step in rebuilding a TV picture tube is to remove the old neck and gun, then fuse on a new neck.

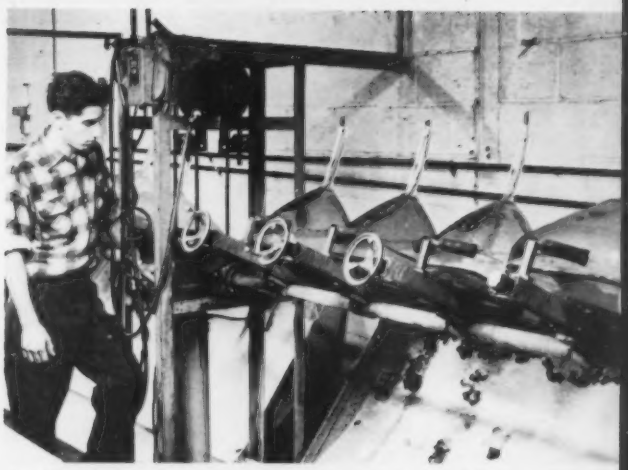
4. The entire inner surface of each bottle is aluminized using vapor deposition in this Stokes automatic dolly.



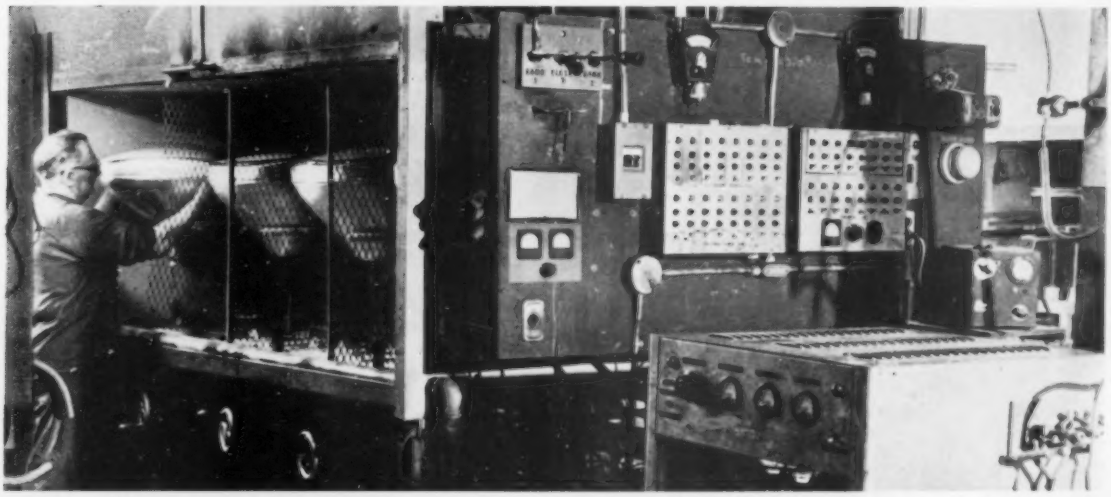
5. New electron guns are automatically fused into the necks of tubes at the rate of one tube every two minutes.

7. The wire leads from each electron gun structure are then assembled into a Bakelite cap which will fit into the appropriate receptacle of the television chassis. This completes the assembly of the picture tube.

2. The old screen and aquadag coating are removed chemically, leaving the glass bottle thoroughly clean.



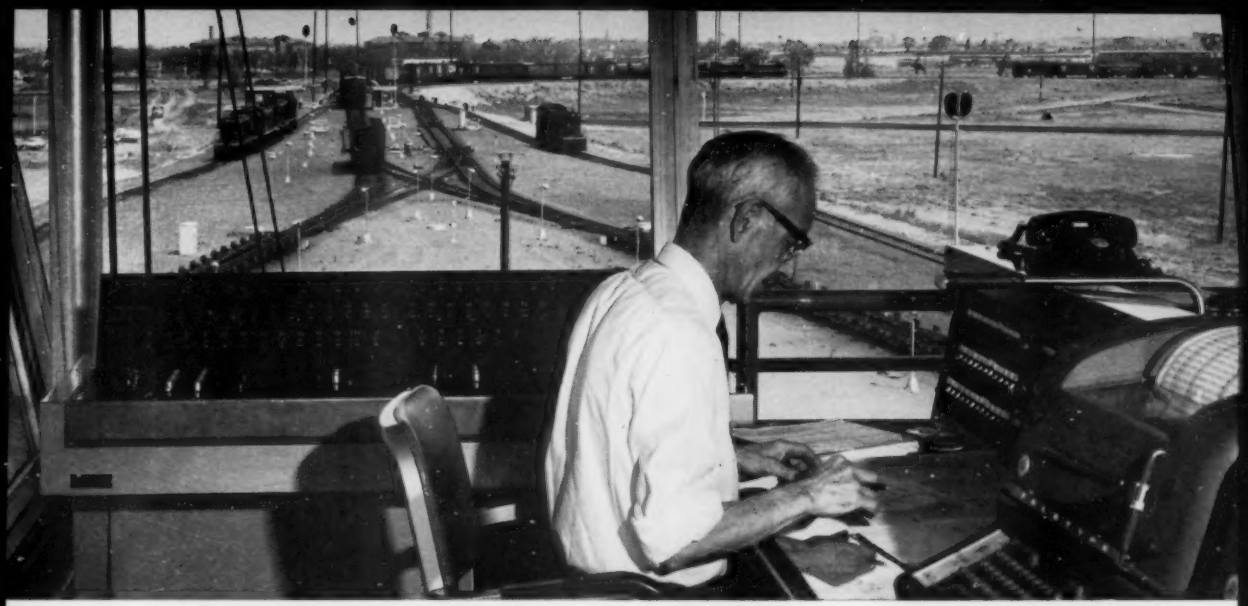
3. New screens are applied by chemical deposition on this ten-position Woodland screen settling tilt table.



6. Eight tubes are loaded simultaneously into each exhaust oven and heated to 400 C. The ovens use Kinney force pumps and Consolidated Vacuum MCF 60 diffusion pumps to remove gas, air and impurities from the picture tubes.

8. Each tube is tested for beam current, grid cut-off, gas ratio, leakage between elements and screen quality.

9. Tube faces are polished to remove fine scratches, then the exterior conductive coating is applied. END



The new $30-million Canadian National Railways Montreal Yard, with 165 miles of track, can move 7,000 freight cars a day. Closed circuit television, computers, teletypes, radar and portable two-way radios for field men are utilized.

What's new in view

Installation of TCA's $3 million ReserVac central registry in Toronto is nearing completion. Operating trials will commence early next year.

In less than six months after its formation, Spectrol Electronics of Canada Ltd., has recruited local production workers, trained them and started production of precision single and multi-turn potentiometers at their Brampton, Ont., plant.

The heart of any precision potentiometer is the resistance element. This special lathe winds bare resistance wire on copper mandrel to get required linear, or non-linear characteristics.

G. Ballantyne (L), past chairman, and S. Reid, newly elected chairman, discuss problems with new committee members E. Mott and C. Simpkins at 10th annual CCBA Engineering Conference.

G. Robitaille (R), chief engineer of CFPL, London was honored for his support of CCBA Engineering Section. C. Eastwood presented plaque.

Toronto played host to the First Annual Meeting of the Communication and Signal Section, Association of American Railroads. Executives from all the major railroads in North America met at the Royal York Hotel, October 2-4.

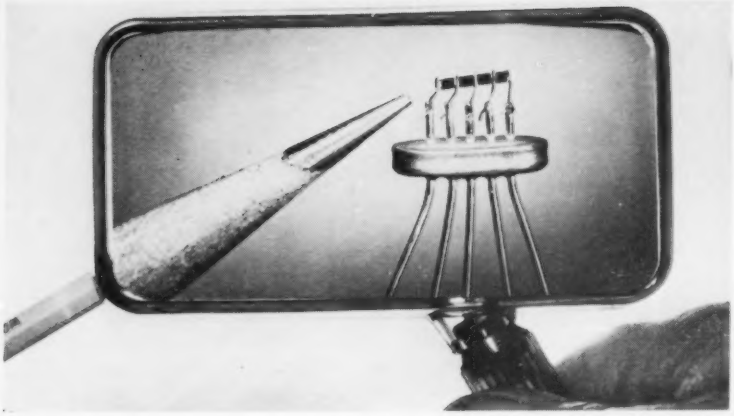
The 1961 Toronto High Fidelity Exposition saw the introduction of a few interesting new design ideas. Harold Leak, right, displayed a new "sandwich" speaker cone developed by his company in London (represented by Eldon Industries of Canada Ltd.). The cone is made by bonding two sheets of aluminum foil (with high tensile strength) to expanded polystyrene. In use, the cone acts as a rigid piston and does not "break-up" as a paper cone does. The new cone weighs about the same as a typical paper cone, shown in Mr. Leak's right hand.

FM stereo broadcasting has sparked sales of tuners and multiplex adapters. One enterprising Canadian company, Creative Electronics Co. Ltd., Toronto, has developed a multiplex adapter which it is fitting on imported Trio tuners.

Raymond V. Pepe, president of the Institute of High Fidelity Manufacturers Inc., New York, spoke highly of the technical standards set at the Canadian show.

"The Dominion High Fidelity Association is to be complimented for its regulations, which require exhibitors of high fidelity equipment to meet basic specification requirements. By so doing they are affording the public a basis of discrimination that we in the United States unfortunately have not as yet accomplished."

New components



Chargistor 101

The Chargistor, an experimental semiconductor device, performs at higher voltages than a transistor does, and has characteristics similar to a vacuum tube. It can be assembled with multi-control elements which act like grids to control the current flow within the device. Operation at 200 volts with greater than 1 Mc frequency response has been demonstrated experimentally in IBM's Advanced Systems Development Div. While the feasibility of the Chargistor as a forerunner of a new class of semiconductor devices has been demonstrated successfully. IBM emphasises that further development work is required.

International Business Machines Co. Ltd., Don Mills, Ont.

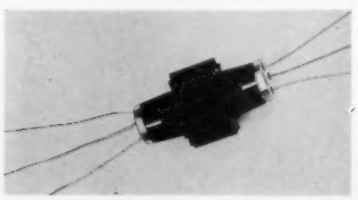
High voltage transistors 102

Three new germanium transistors have been introduced with characteristics which offer greater latitude in high-voltage circuits. Types 2N1924, 2N1925 and 2N1926 have voltage ratings up to 60 volts and exhibit high gain characteristics. They may be used in audio frequency switching circuits as well as high voltage amplifier circuits.

Canadian General Electric Co. Ltd., Toronto.

Double-ended transistor radiators 103

Double-ended combination radiators and retainers for mounting TO-5, -8, -9, -11, -12, -29, -33, -37, -38, -39, -42, -43 and other transistors have been introduced by The Birtcher Corp. In addition to conventional mounting requirements, the devices have tapped bases for quick mounting in flip-flop or push-pull circuits. Sides of mounting holes are slotted to accept transistor case diameters from 0.310-0.325 inch, and 0.475-0.490 inch. The multi-fin design reduces heat up to 27%.



Lake Engineering Co. Ltd., Scarborough, Ont.

Matched diode package for SSB applications 104

To meet the trend to single sideband commercial transmission, Ohmite Mfg. Co. now offers a matched diode quad for use as a ring modulator, or discriminator in SSB equipment. The four gold-bonded, hermetically-sealed-in-glass germanium diodes are matched in pairs and then pairs matched to pairs to obtain a carefully-balanced assembly. Matching is maintained over a wide range of voltages and frequencies. Diodes are selected so as not to load down input circuits. Temperature range is —65 to +90 C.

A. C. Simmonds & Sons, Ltd., Toronto; C. M. Robinson Co., Winnipeg.

Low-noise oscillator klystrons 105

A new line of low-noise oscillator klystrons has been introduced for applications in CW illuminators, fixed-frequency doppler navigation transmitters and similar systems. The VA-511 produces 50 watts minimum power at 10.0 Gc and operates at 10 kv, 60 ma. This fixed-frequency two-cavity oscillator has an FM noise figure less than 1 cps, and is electrostatically focused.

Varian Associates of Canada Ltd., Georgetown, Ont.

(Continued on page 68)

New instruments

Portable moisture meter 106

Beckman Hygromite is a portable moisture meter designed to measure trace quantities of moisture in gases. It monitors water vapor continuously in ppm ranges of 0-10, —30, —100, —300 and —1000 with accuracy of ± 5% of full scale in any of the ranges. A hydrogen electrolytic cell permits accuracy of a high degree on gases with hydrogen concentrations exceeding 50%. In samples containing no hydrogen or concentrations of hydrogen less than 50%, the standard electrolytic cell is used to remove and electrolyze water in the samples.

Industron Corp., Toronto.

Direct reading frequency meter 107

FXR waveguide frequency meter, model S60-13, has been designed for use in the 7.5 to 9.6 Gc range. The meter offers continuous high resolution over the entire frequency range with 1 Mc as the least dial division. Accuracy of ±1 Mc is maintained throughout the temperature range of +32 F to +85 F. At resonance there is a nominal dip of 20% in the power level on the main waveguide. Simultaneously, a signal 20 db down from the level in the main waveguide is fed to a coaxial crystal mount coupled to the resonant cavity. Frequency readings are taken directly from the spiral scale.

Radionics Ltd., Montreal.

Instrument measures surface finishes 108

Brush model MS 1000 Surfindicator is a portable, battery-powered instrument for measuring surface finishes on metals, plastics, ceramics and organic materials. Measurements from 1 to 1000 microinches can be made at any point in a

New equipment

production line or inspection area. The stylus, capable of detecting variations of ½ microinch within the measurement range, contains a transducer element which generates a current proportional to surface variations. As the stylus tip is moved over a test surface, small deflections are transmitted through a viscous fluid coupler to the current generator inside the pickup.

A. C. Wickman, Ltd., Toronto.

Differential polarograph 109

Nash & Thompson differential cathode ray polarograph is a production version of equipment developed at the U.K. Atomic Energy Authority. It has two identical polarographic cells which can be used separately or together. The DCRP can be used as an analytical tool for chemical and metallurgical examinations of many kinds. When used as a

means of detecting impurities in foodstuffs, the DCRP can identify traces of metals at concentrations as low as 0.02 parts per million and can carry out quantitative analyses to an accuracy of ±1% to ±2% in solutions containing 1 part per million of the species being investigated. Power supply is 110 or 220/250 volts ac.

Electrodesign, Montreal.

HF transfer voltmeter 110

Ballantine's Model 393 is a transfer device by means of which an unknown ac voltage may be measured with high accuracy in terms of a dc voltage. The design is such that the transfer impedance of the probe is uniform from 25 cps to 30 Mc. Its primary uses will be in standards laboratories for calibration of rf signal sources, rf voltmeters, and the frequency response of amplifiers or other devices.

Bayly Engineering Ltd., Ajax, Ont.

(Continued on page 71)

Mobile radio 111

Model DT65 VHF FM mobile radio unit will operate in the 148-174 Mc range and is intended for use on vehicles provided with 12-volt systems. Features include: transistor "burn-out" protection, built-in voltage regulator, transistorized power control and audio circuits, full transmitter current drain of 10.5 amps at 13.6 volts for 30 watts output. It has one-to-six channel flexibility.

Canadian Marconi Co., Montreal.

Power line filter 112

McMillan model D-60 power line filter is designed for use on industrial electrical equipment such as welders, x-ray equipment, induction heating equipment, etc., and provides suppression of rf interference which many of these machines broadcast. Its characteristics are: 50 amps at 250 vac, 400 cps; 60 amps at 250 vac, 60 cps; 70 amps at 600 vdc; 100 db or better from 100 kc to 45 Gc.

David R. Beattie, Toronto.

Servo amplifier 113

Model EAPS-A-10 amplifier for use in electro-hydraulic servo systems, includes a built-in regulated power supply and is impedance matched for operation with all standard Vickers-Sperry industrial servo valves. Intended load is 3-watt permanent magnet motor with coils having 2,200 ohms per side. Static gain is 80 ma/volt continuously variable down to 1 ma/volt. Input impedance is 100,000 ohms. Low level signal sensitivity is less than 30 uv.

Vickers-Sperry of Canada Ltd., Toronto.

Speech plus duplex telegraph equipment 114

This transistorized speech and duplex telegraph equipment gives high electrical performance, low power [illegible]n, flexibility of performance and e[illegible]tallation. Line current is 20/60 [illegible]ut requirements are 12 vdc, 24 [illegible] 90 to 250 vac, 40-60 cps. Power consumption is 3 watts.

Etelco Canada Ltd., Scarborough, Ont.

TV broadcasting system 115

This "package" television broadcasting system, which can be bought for as little as $65,000, has been specially developed to bring television to smaller communities. Entertainment, news and general TV programming can be originated with a minimum of staff. The "Cambridge Station," as the equipment will be known, includes studio, control room, telecone, transmitters, tower, antenna and all other equipment necessary for operation of the station.

Pye Canada Ltd., Transmission Div., Ajax, Ont.

Laboratory standard antenna set 116

Empire Devices model SA-301 standard antenna set permits laboratory standardization of field strength from 10 kc to 300 Mc. The set, when used with an RF signal source, is complete with all items needed to perform calibration. Components furnished include all necessary loop and dipole antennas, baluns, tripods, precision meters, cables and accessory items.

Instronics Ltd., Stittsville, Ont.

Channel 1 regulator panel 117

Type 331A Channel 1 Regulator Panel for automatic frequency synchronization and signal level regulation has been introduced for use on Channel 1 of the Lenkurt stackable three-channel Type 33A multiplexing system. It was developed to meet the new requirements of frequency shift telegraphy which is scheduled for large-scale use next year in the United States. Regulation circuitry effects a 5:1 ratio of output improvement over received line signals. Absolute synchronization is produced.

Lenkurt Electric Co. of Canada Ltd., Burnaby, B.C.

Linear accelerator is planned for University of Saskatchewan

The National Research Council and the University of Saskatchewan Board of Governors have recently made funds available to the University of Saskatchewan Physics Department for a linear electron accelerator and the erection of a building to house this machine and provide the ancillary research space.

The accelerator will cost $750,000 and the money will be donated by the National Research Council. A structure to house it will be provided by the university at a cost of some $400,000 to $600,000.

Dr. Leon Katz, professor of physics, has been largely responsible for planning and design for the accelerator. Others closely connected with the project, who will make use of the facilities, are Dr. R. N. H. Haslam, professor of physics, and Dr. K. J. McCallum, professor and head of the Department of Chemistry. Also using the unit will be research groups in medicine and engineering.

Prof. Katz said it will likely be the end of 1963 before the unit will be in use. "It can be assembled in about one year," he said, "but we'll need more time than that to prepare the experiments which will use the machine's electron beam.

"Preliminary discussions with prospective machine manufacturers indicate that an accelerator of the following characteristics may be purchased with the funds available.

"It will be a traveling wave machine composed of 8 separate accelerating sections each about 1.5 meters long operating in the $2\pi/3$ TM mode. These will be powered by four S-band (2,856 Mc) klystron amplifiers of the type to be used on the Stanford University 2-mile linear accelerator (Project M). Each klystron, delivering approximately 26 Mw peak and 22 kw RF power average, has two output windows and will thus feed two of the accelerator sections.

"An unloaded (zero beam current) energy of 150 MeV is anticipated and, when loaded to deliver 40 kw of beam power, the energy should be in excess of 100 MeV. Single shot operation is specified as well as repetition rates of 1,000 cps or greater.

"One feature of this machine will be the availability of exceedingly narrow pulses at the higher repetition rates. Widths of 10 nsec are being specified in the design, although according to recent technological advances pulses as narrow as 1 nsec are confidently expected. The beam current in the narrow pulse is expected to exceed 2 amp. Pulse widths may however be varied up to 1 nsec with correspondingly lower repetition rates.

"Since the S-band machine operates at 3×10^9 cps in the RF and the electrons are bunched on the crest of each RF cycle with a phase spread of 20°, the electron beam is composed of individual electron bunches each 2×11^{-11} sec. in duration with a 1/3 nsec spacing between them. A 1 nsec pulse, as mentioned above, will thus be composed of 3 to 4 such bunches, each carrying 25 amp. That is, each bunch is ½ cm diameter, ¾ cm long and contains 3×10^9 electrons.

"The energy of the electron beam will be continuously variable from 5 to 150 MeV.

"Experiments in nuclear physics and radiation chemistry are being planned. Intense beams of protons, electrons and neutrons will be available for these."

Two of the men behind the new accelerator

Katz

Haslam

Dr. Leon Katz, professor of physics, has been appointed director of the new accelerator laboratory at the University of Saskatchewan. He will be responsible for installation and operation of the new linear electron accelerator.

Prof. Katz, 52, was born in Poland. He attended high school in Toronto, and received his BSc and MSc degrees from Queen's University. He received his PhD degree from the California Institute of Technology. In 1946 he joined the U. of S. faculty.

Prof. Katz is a Fellow of the Royal Society of Canada; Fellow of the American Physical Society; member of the Canadian Association of Physicists Executive Committee; a member of the Physical Society (Great Britain); secretary of the sub-committee on Nuclear Constants of the American Academy of Science — National Research Council.

He was chairman of the Canadian Association of Physicists committee to acquire a high energy machine for Canada. He was one of the Canadian delegates to the 2nd International Conference of the Peaceful Uses of Atomic Energy and was the only Canadian invited to attend the All Union Conference of the Academy of Sciences of the U.S.S.R., 1957.

Professor R. N. H. Haslam, 51, was born in Toronto and received his BA and MA degrees from the University of Saskatchewan. After obtaining his PhD degree from McGill in 1933, he studied until 1935 at the University of Leipzig on an Exhibition of 1851 scholarship. He joined the U. of S. faculty in 1935 and is the current president of the Faculty Association.

In 1954 Prof. Haslam was elected a Fellow of the Royal Society of Canada. He is a member of the American Physical Society and has served on several committees of the Canadian Association of Physicists.

Prof. Haslam has just been appointed head of the Dept. of Physics at U. of S. He succeeds Prof. Currie who has relinquished the headship to allow him more time to devote to his other responsibilities as Dean of the College of Graduate Studies and Director of the Institute of Upper Atmospheric Physics.

Prof. Haslam is a member of the Operating Committee for the Accelerator Laboratory.

ISA Toronto Section meetings

Measurement and control in Canada's major industries will be the centre of attention in the coming year's technical program announced for the Toronto Section of the Instrument Society of America. Dates, program, and arrangements for the meetings are as follows:

Nov. 28: A symposium dealing with the food industry. Chairman will be P. Moyes, editor of Food in Canada. The meeting will be held in the Westbury Hotel (dinner meeting).

Jan. 24: Mr. Schmidt of Canadian Bechtel Ltd. will speak on "Recent trends in control panels" (for the petrochemical industry). Meeting place will be announced later.

Feb. 28: Meeting will be concerned with atomic power.

March 22: Program will be for the pulp and paper industry.

April 25: Basic steel industry will be featured.

The programs and meeting places for the last three meetings have not yet been established.

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For your library

Two new texts provide foundation for studies in electromagnetism

Electromagnetic Fields, Energy and Forces (520 pp; $12.00)

Electromagnetic Energy Transmission and Radiation (621 pp; $14.50)

Robert M. Fano, Lan Jen Chu and Richard B. Adler; John Wiley & Sons, Inc., New York.

These two text books on electromagnetism were developed for the junior and senior years of the undergraduate "core curriculum" at M.I.T., and are intended to form a scientific foundation of the subject upon which the student may later build his specialized technology.

"Electromagnetic Fields, Energy, and Forces" is a text for a one-term junior subject which assumes the usual elementary physics preparation in electricity and magnetism. The vector algebra necessary for the study of fields is introduced in the early chapters. The starting point for the field theory is Maxwell's equations, which are developed in both the integral and differential form using vector methods. Electrostatics and magnetostatics are both developed as static field problems, first in free space and then in the presence of material bodies. The authors then proceed to time-varying fields with special attention being given to the connection between field theory and electric circuits. Thus a chapter is devoted to the storage of energy in fields and to the flow of power in circuits, and another to the field behaviour of circuit elements in the sinusoidal steady state. The closing chapter introduces the force and energy relations between electromagnetic fields in systems with moving bodies, as the basis for electromechanical energy conversion.

"Electromagnetic Energy Transmission and Radiation" is the text for a one-term subject on electromagnetic wave phenomena. The opening chapters review the field and circuit concepts developed in the previous text, especially sinusoidal fields and distributed circuits. The first half of the book deals with electromagnetic waves on transmission lines, including steady state and transient waves on both lossless and dissipative lines, and the phenomena of standing waves and resonance. The authors make use of the energy and power points of view to show the connection between circuit and field concepts. The remaining half of the book deals with plane wave phenomena in lossless and dissipative media, the transmission of transverse electromagnetic waves, and the elements of radiation.

These two volumes give a comprehensive coverage of quite conventional subject matter in a manner which is both stimulating and refreshingly new. Having committed themselves overwhelmingly to the teaching of principles of lasting value, the authors could not at the same time produce a technical work for practical reference. Thus, carefully chosen but elementary examples are examined from many points of view in order to establish the physical concept, but without any reference to quantitative practical application. The authors have also avoided producing a text which is an exercise in vector mathematics, but have examined each topic from the points of view of the time-domain, frequency-domain, field concepts, circuit theory, the conservation of energy, and power flow. The

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texts undoubtedly contain considerable material beyond a classroom course and their thorough treatment will answer the questions of the best students.

Reviewed by H. C. Ratz, Assistant Professor of Electrical Engineering, University of Saskatchewan.

Medical Electronics

Proceedings of the Second International Conference; C. N. Smyth, Editor; Iliffe & Sons Ltd. (British Book Service [Canada] Ltd., Toronto); 614 pp; $26.10.

Of the 160 papers delivered at the Conference, 80 are presented in full in this volume and 71 are presented in much shorter form as abstracts. The subject matter is grouped under headings of Electrophysiological Techniques, Electroencephalography, Cardiology, Manometry and Flow Measurement, Acoustic Techniques, Automation in Medicine, Radiology and Isotopes, and Chemical Instrumentation.

A wide range of subject matter has been presented and, as stated in the editor's preface, it is most useful as . . . "a book in which to discover what work is going on, where and by whom".

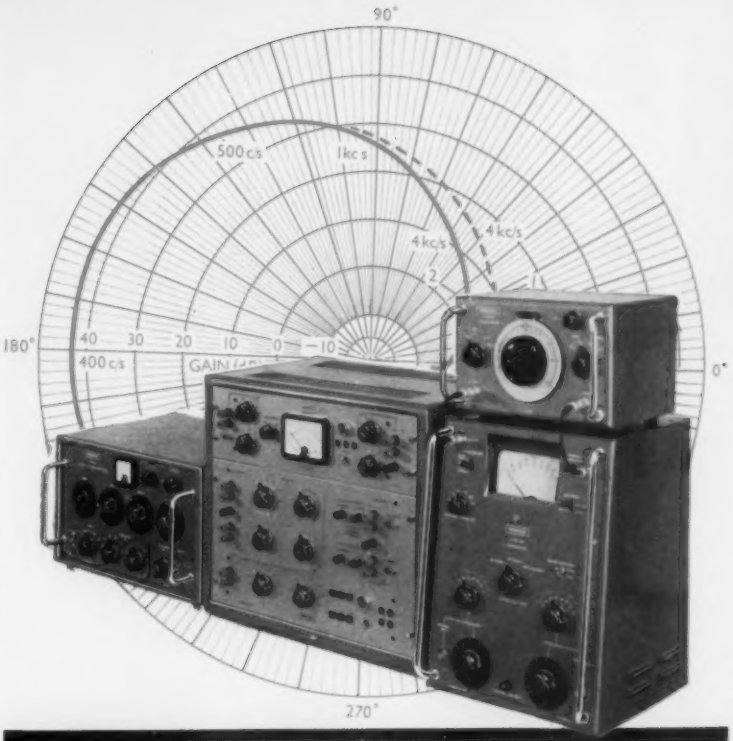
Succeeding conferences, which seem to be taking place annually, have abandoned the post conference publication in favour of a "Digest" available for the conference. However, in view of the care in which papers have been chosen for publication in this volume it still represents a good source for preliminary information in any of the fields outlined. Those who take active part in a particular small area of research may find that their own field is presented in an incomplete, or possibly an outdated fashion, which is inevitable in any rapidly developing field of endeavour.

The international character of the conference and the papers presented should bear careful study because it reflects the work of some very capable Europeans and strengthens the feeling that North America has no monopoly in ingenuity and skill in the field of Medical Electronics.

The range of subject matter is so broad that no one paper or group of papers should be singled out for comment, and a discussion of all of them would be impossible in a review.

On the whole the aim of the editor has been well attained and the volume should justify its place in every medical library.

Reviewed by W. Paul, Associate Professor, Dept. of Pathological Chemistry, University of Toronto.



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Ask for Publication 109—it describes the equipment in detail.

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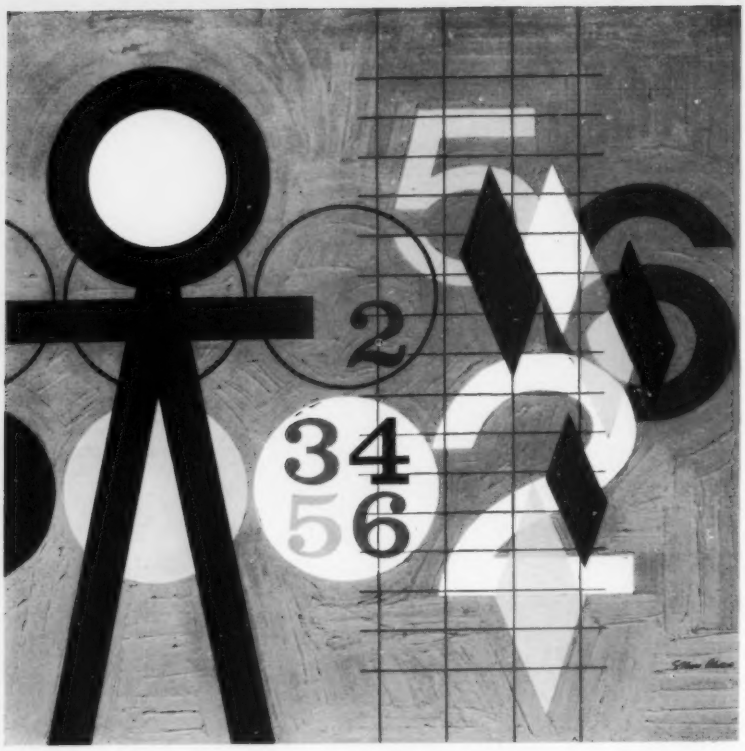

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Reports—continued

Barker Products Co. of West Bridgewater, Mass. has appointed Alex L. Clark Ltd. its sales representative for all Canada except B. C. A complete line of audio cables and connectors will be stocked in Canada.

Power Service Products, P.O. Box 184, Islington, Ont. has been appointed Canadian representative for **Metron Instrument Co.** of Denver, Colorado. Metron manufactures miniature variable speed and differential drive assemblies and similar equipment.

Douglas Randall (Canada) Ltd. has been named technical sales representative for **National Beryllia Corp.** in Canada (beryllium oxide ceramic).

Fred Eaton Sales Agency has been established at 2154 Primate Road, Cooksville, Ontario.

Instru-Lec Corp., Mount Vernon, N.Y., manufacturer of precision gears and differentials, has appointed M. J. Howard & Co. Ltd., as its sales representative in Canada.

Metal Industries Ltd. forms new company in Canada

Dominion M. I. Ltd. is a new company established by Metal Industries Ltd. of England. The Canadian company, with its head office and plant at 8355 Mountain Sights Avenue, Montreal 9, was formed following the dissolution of Bepco Canada Ltd. Bepco was a consortium of British electrical manufacturers, which included Lancashire Dynamo Holdings, an M. I. subsidiary.

Tamblyn

Chandler

Dominion M. I. Ltd., which began operations Nov. 1, will be concerned with the promotion of M. I. Group's products in the Canadian market, and with the manufacture of specialized electrical control systems and equipment. President and general manager of the new company is E. A. Chandler; general sales manager is D. J. Tamblyn.

Elder forms consulting service

J. Gordon Elder is now in independent practice under the name of Gordon Elder Consulting Service. He specializes in broadcast and communications systems engineering, including directional antenna design,

performance appraisal tests, and equipment type testing. Mr. Elder has a BSc degree in electrical engineering from Glasgow University and an MCom degree in business administration from the University of Toronto. His address is 129 Manor Rd. East, Toronto 7. (HU 3-9096.)

Ottawa—continued

turing; communications equipment by Radio Engineering Products; and rocket vehicles by Bristol and Canadair.

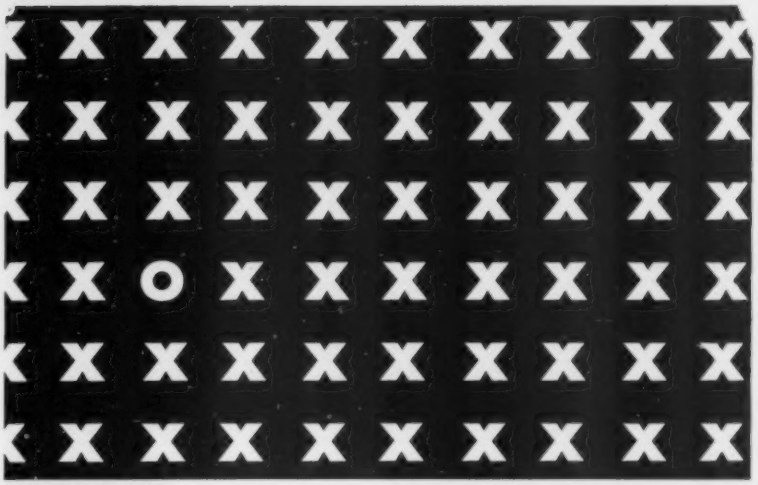
O'Hurley gave this list of prime contracts: Aircraft and spares for De Havilland Caribou aircraft, $7.7 million; engine spares, repair and overhaul to Pratt and Whitney, $11.7 million; sonobuoys to Sparton, $1.1 million; cartridges to Canadian Arsenals, $3.9 million; field telephones to Radio Engineering Products, $1.6 million; engine development to Orenda, $913,000; plotting tables to Marsland Engineering, $2.6 million. In addition Canadian Marconi had received a firm order for airborne doppler navigation radar worth $370,000 and negotiations were under way to increase this to $1.7 million. "There are good prospects for additional large orders," he added.

Among subcontracts: Countermeasure systems to Northern Electric, $1.2 million; switchboards for the FPS-26 to Federal Pacific, $830,000; radar equipment to Canadian Westinghouse, $2.3 million; NASARR subsystems to Westinghouse, $3.5 millio..; training and installation AN/FST-2B (SAGE) to Burroughs, $1 million; missile components to Sperry, $2.7 million; and Bomarc parts and components to several companies, $1.3 million.

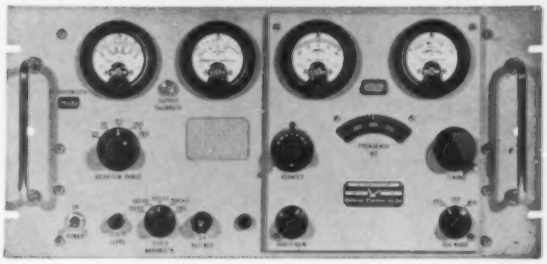
Another type of program operated by the department, said O'Hurley, was that under Vote 71 to establish qualified sources for component parts and materials. Since it was set up in October 1958 more than $860,000 had been spent; 28 contracts had been placed and of these 12 had been completed. In addition a further 18 projects are under consideration covering such items as basic ceramic and precision bearing facilities to transistors, fuel pumps and servo-synchro components.

The operation of this program, he said, "shows clearly that Canadian industry is capable of producing new military components to acceptable standards."

This year Vote 71 amounts to $607,000 with a commitment authority for an additional $300,000.



WHAT MAKES ONE OUTSTANDING? THE TMR-2A



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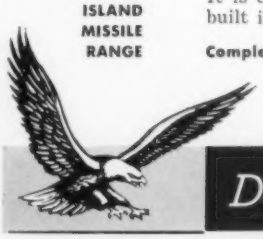

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DETAILS ON
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R O R

Hollow-cathode discharge tubes 118

These hollow-cathode discharge tubes for atomic absorption spectroscopy are available for analysis of materials containing iron, copper, nickel, zinc, manganese, magnesium, calcium and other

elements. The tubes are used as sources of characteristic radiation of the element to be analyzed. They feature low starting voltage, low operating voltage and stable current. The output spectral lines are narrow and steady after a short warm-up period. Five tube types are currently available from stock; special tubes with variations of cathode material, gas fill and output window are available on request.

Canadian Westinghouse Co. Ltd., Electronic Tube Div., Hamilton.

Interlocking cable markers 119

Helagrip interlocking cable markers are made from high quality flexible PVC and are designed for fitting, without the aid of tools, cables with outside diameters from ⅛ in. to 7/16 in. The interlocking feature assures alignment of characters even when the cable is turned at 90 degrees. The standard color is white with black printing. Markings A to Z and 0 to 9 are available from stock. They are supplied in strip form partially cut to ensure correct positioning of marker.

Hellermann Canada Ltd., Scarborough, Ont.

Silent potentiometer 120

Rayvistor CK1114 is designed for a switch, relay or potentiometer application in circuits requiring minimal space and power. It is a pedestal-free switch and uses a tiny incandescent bulb as the control element, with a miniature

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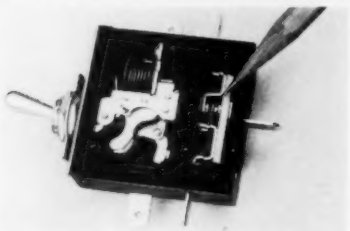
photosensitive resistor as the signal element. When illuminated with power of only 25 milliwatts at 1 volt, the photosensitive cell changes its resistance value from 3 x 10^8 ohms to 460 ohms. Designed to withstand up to 60 vdc across its terminals, the signal circuit will dissipate up to 50 mw. Either ac or dc supplies may be used to drive the control circuit for switching either ac or dc signals. It is sealed in a transistor case.

Raytheon Canada Ltd., Waterloo.

Breaker has auxiliary alarm contacts 121

A new model of the Heinemann series VP circuit breaker has miniature snap-action contacts that can operate a signal light or alarm. The auxiliary contacts on the new VP-3HE breaker are enclosed within the breaker case but are electrically isolated. They are actuated mechanically by the breaker switching mechanism. Contact ratings are 5 amps, 125 volts and 2.5 amps, 250 volts, 60 cps, resistive; and 1 amp, 50 vdc, resistive. The breaker is magnetically operated and available in a choice of three overload responses. It can be supplied with a fast or slow hydraulically-controlled inverse time-delay, or with instantaneous response.



F. D. Bolton Ltd. & Douglas Power Equipment Ltd., Vancouver; D. T. Shaw, Montreal.

Cerafil capacitors for potted circuits 122

Special ¼ in. long Cerafil capacitors in 10-1,000 pf capacities are available for premium space applications, such as sandwich-type circuit construction. The capacitors are made in lacquer coated, durez coated or epoxy molded cases, depending on diameter and/or test requirements.

Aerovox Canada Ltd., Hamilton.

Copper-clad epoxy paper laminate 123

Phenolite Grade EP-492-1 is a new grade of copper-clad epoxy paper base laminated plastic for printed circuit manufacturing. Average values of 1/16 in. thick specimens are: flexural strength lengthwise is 25,000 psi, crosswise is 23,000 psi; impact strength lengthwise is .59 ft lb/in., crosswise is .58 ft lb/in.; water absorption rate is .44% in 24 hours; dissipation factor (at 1 Mc) is .031; dielectric constant (at 1 Mc) is 4.17; insulation resistance is 190,000 megohms.

National Fibre Co. of Canada Ltd., Toronto.

(Continued on page 71)

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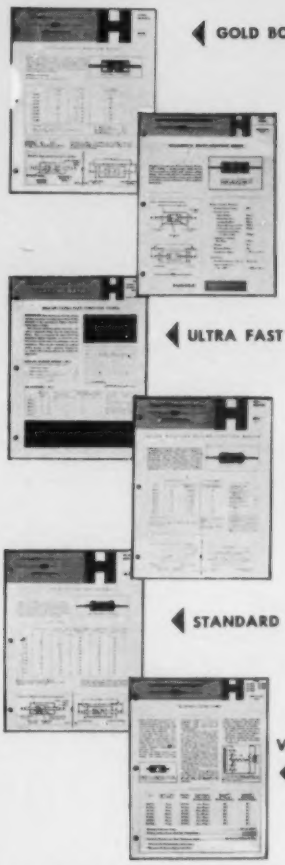

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These units exhibit fast recovery and low Reverse leakage. Rated inverse from 30 to 70V, all units having forward drop of 0.8 volts at 100 mA.

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With peak inverse of 75 or 100V, 45 mA forward current, these units have high back resistance and excellent recovery characteristics.

ULTRA FAST SILICON COMPUTER DIODES — 5 TYPES

Maximum recovery time not exceeding 0.5 milli-microseconds and 20 volts reverse characterize these units for high speed computers and U.H.F. equipment.

QUICK RECOVERY SILICON JUNCTION DIODES — 6 TYPES

Peak inverse from 50 to 150 volts, 40 to 80 mA forward current and 0.3 microsecond recovery are features of the fast diode line.

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The "workhorse" line with characteristics from 50 to 200 peak inverse volts, 50 to 200 mA forward and extremely high back resistance.

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ELECTRONICS DIVISION
TORONTO 15, ONTARIO

6102

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CAMESA News

This bulletin has been prepared for CEE by the Specifications, Approvals and Electron Devices Divisions, and the Test Equipment Section, Canadian Military Electronics Standards Agency, Ottawa.

▸ A new specification, MIL-R-22684 (NAVY), has been issued recently. It covers tin oxide resistors, which are physically similar to the composition resistors covered by MIL-R-11C, but with much greater stability. They are suitable for applications where the expense of deposited carbon resistors is not warranted.

▸ Also in the field of resistors, specification MIL-R-10509D, covering fixed film high-stability resistors, has been adopted by the Canadian Armed Forces. This specification supersedes MIL-R-10509C and incorporates many changes. Among them are five new temperature ratings, and four new resistance temperature characteristics. The acceleration test has been deleted as test data have shown that no failures have occurred as a result of it. Canadian Military Preferred List PL-R-10509D has been issued in conjunction with this specification.

▸ Amendment 3 to specification MIL-C-5B, covering fixed mica dielectric capacitors, has been issued recently. Included in the same issue are Supplement 1A and a number of revised detail specifications. The amendment changes all tests originally applied only to molded styles, to cover both dipped and molded construction. Also the insulation resistance requirements after environmental testing are tightened for both molded and dipped capacitors. A great many other changes have also been made.

▸ Specification MIL-T-152A, covering moisture and fungus resistant treatment of electronic equipment is now replaced by MIL-T-152B. The new version provides for both limited and over-all treatment, and the list of items to be protected against varnish application has been expanded. Requirements for workmanship have been defined, and a list of fungus-inert materials has been added.

▸ During the month of September three Canadian companies secured listings in U. S. Qualified Products Lists for 22 items. These included transformers, radio frequency inductors and film resistors.

▸ The JCNAAF Preferred and Guidance Lists of Electron Tubes (PL-TUB-1) and Semiconductor Devices (PL-SEM-1), are now being distributed and extra copies are available on application to CAMESA.

▸ Our laboratory has now checked out a purely optical system for checking the sensitivities of accelerometers used in vibration tests. Displacements corresponding to 10g at 2,000 cps can be observed directly and used for calibrating accelerometers. The present accuracy obtainable is 7% at 2,000 cps, 5% at 1,000 cps and 1% at 400 cps. An overall improvement to 5% at 2,000 cps is expected after further work. It is anticipated that this facility will be available for checking accelerometers belonging to manufacturers engaged in tests for submission to us. A detailed report will be available within six weeks.

Defence contracts

Unclassified electronics contracts for $10,000 or more have been awarded to the following Canadian firms by the Department of Defence Production. A figure in parentheses indicates the number of contracts, the amount being the total value.

September 1-15, 1961

▸ Ampex of Canada Ltd., Ottawa, components, $17,115.

▸ Bell Telephone Co. of Canada, Ottawa, lease of communication circuits, $1,159,374 (14).

▸ British Columbia Telephone Co., Vancouver, installation of telecommunication equipment and associated on-base cabling, $343,128 (4).

▸ CTS of Canada Ltd., Streetsville, Ont., eddy current compensators, $64,514.

▸ Canadian Admiral Corp. Ltd., Port Credit, Ont., radiac detector chargers, $26,918.

▸ Canadian General Electric Co. Ltd., Toronto, tubes, $12,258.

▸ Canadian Marconi Co., Montreal, airborne radio communication equipment, $17,478; magnetrons, $205,699 (2).

▸ Canadian National Railway Co., Ottawa, lease of communication circuits, $45,786 (2).

▸ Canadian Westinghouse Co. Ltd., Ottawa, product improvement modifications to mobile tropospheric scatter equipment, $10,814; components, $20,252.

▸ Computing Devices of Canada Ltd., Ottawa, components, $70,452.

▸ E.M.I.-Cossor Electronics Ltd., Dartmouth, N.S., telecommunication spares, $12,839.

▸ Anthony Foster & Sons Ltd., Toronto, radio compass equipment, $30,505.

▸ Garrett Mfg. Ltd., Rexdale, Ont., research, development and supply of a partial pressure measuring device, $32,969; equipment, $347,699.

▸ Instronics Ltd., Stittsville, Ont., equipment, $102,181.

▸ Marsland Engrg. Ltd., Kitchener, Ont., modification of plotting tables, $490,357.

▸ Micro-Tower Ltd., Scarborough, Ont., antenna supporting structures, $356,437.

▸ New Brunswick Telephone Co. Ltd., Saint John, installation of telecommunication equipment and associated on-base cabling, $66,032.

▸ Northern Electric Co. Ltd., Ottawa, spares for telephone system, $15,927; transmitting and receiving antenna, $37,876.
▸ Ontario Northland Communications, North Bay, lease of voice frequency buried cable communication system, $38,507.
▸ Philco Corp. of Canada Ltd., Don Mills, Ont., telegraph and alarm control selectors, $325,161 (2).
▸ R-O-R Associates Ltd., Don Mills, Ont., frequency meters, $17,105; frequency counters, $37,631; electronic counters, $72,418.
▸ Radionics Ltd., Montreal, multi-channel pulse height analyzer, $16,760.
▸ Sperry Gyroscope Co. of Canada Ltd., Montreal, fixed sensing element, $24,218; marine loran equipment, $26,448.

September 16-30, 1961
▸ Aircraft Appliances & Equipment Ltd., Rexdale, Ont., test sets, $18,465; spares for motor generator sets, $20,539; components, $66,860.
▸ A. T. R. Armstrong Ltd., Toronto, spares for motor generator sets, $12,858.
▸ Bell Telephone Co. of Canada, Ottawa, rental of interexchange data circuits, $90,140 (6).
▸ Burgess Battery Co., Niagara Falls, Ont., batteries, $18,374.
▸ Canadian Aviation Electronics Ltd., Montreal, spares for flight simulators, $25,000.
▸ Canadian General Electric Co. Ltd., Toronto, components, $15,343.
▸ Canadian Marconi Co., Montreal, field test equipment for airborne doppler equipment, $200,703; high frequency radio communication equipment, $16,035; radar test sets, $11,350.
▸ Canadian Motorola Electronics Co., Toronto, radio transmitter - receivers, $12,755.
▸ Collins Radio Co. of Canada Ltd., Toronto, test sets, $14,788.
▸ Computing Devices of Canada Ltd., Ottawa, time of flight mass spectrometer, $36,442; technical representative, $10,000.
▸ Electronic Marketing Co. Ltd., Montreal, signal generators, $57,562 (2).
▸ Litton Systems (Canada) Ltd., Rexdale, Ont., telecon spares for aero engine, $62,266; maintenance spares for aero engines, $56,991.
▸ Maritime Telegraph & Telephone Co. Ltd., Halifax, installation of telecommunication equipment and associated onbase cabling, $90,552.
▸ Northern Electric Co. Ltd., Ottawa, maintenance spares for telephone switchboards, $332,575; teletype spares, $10,000.
▸ R-O-R Associates Ltd., Don Mills, Ont., recording systems, $28,924.
▸ Radio Engrg. Products, Montreal, telephone terminals, $617,213.
▸ Radionics Ltd., Montreal, portable frequency counters, $17,800.
▸ Raytheon Canada Ltd., Waterloo, Ont., tubes, $31,764.
▸ Stark Electronic Instruments Ltd., Ajax, Ont., signal generators, $67,120 (3).

Agents and lines wanted

Vactric (Control Equipment) Ltd., 30 Bouverie Street, London, E.C.4 is interested in obtaining representation in Canada. The company was recently purchased by the News of World Publishing Company, and wants to expand its sales in North America. Products are precision rotary and sampling switches, servo motors, gearheads and breadboard components. The export sales engineer is Mr. L. Nash.

New instruments—cont.

Dynamic balancer 124

This precision dynamic balancer, introduced by Micro-Poise Engineering & Sales, has a weight range from 1/3 oz. to 120 oz. with sensitivity better than 0.001 in.-oz. The instrument has a portable control panel and pick-off points which can determine the state of unbalance in a completely assembled and operating unit.

Canavia Engineering & Sales Co., Malton, Ont.

Four-trace preamplifier 125

Seventeenth in the "letter-series" of plug-in units, the new Type M unit adds multiple-trace displays to the wide range of applications possible with Tektronix oscilloscopes. Independent controls for each amplifier channel permit the operator to position, attenuate and invert input signals as desired.

Tektronix, Inc., Willowdale, Ont.

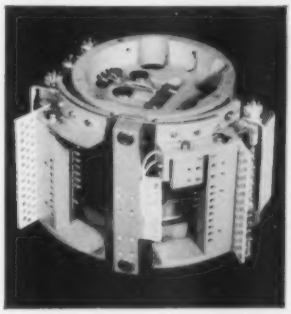
Rectangular panel meters 126

Beckman Style 42 (4½ in. rectangular) panel meters are available in 95 standard models of voltmeters, ammeters, milliammeters and microammeters. Accuracy of dc and ac models is 2% of full scale value. All standard ac meters are calibrated for 60 cps sine wave.

Helipot Division of Beckman Instruments, Inc., Toronto.

FERRANTI FP PACKARD

electronics



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This magnetic storage drum was developed, designed and manufactured for application in an airborne computer—just one of the many digital components and systems originating at Ferranti-Packard.

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- Magnetic storage drums
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ELECTRONICS DIVISION
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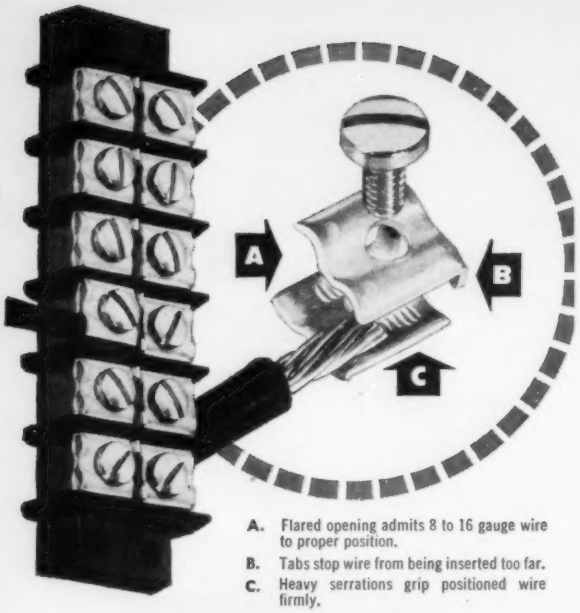

A. Flared opening admits 8 to 16 gauge wire to proper position.
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C. Heavy serrations grip positioned wire firmly.

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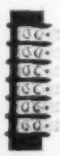
Rapid installation—Positive Connections without costly wire terminals!

Designed and developed in Canada with patent pending*, the Quick-Clamp Barrier Terminal Strip is a new exclusive product of the United-Carr Fastener Company of Canada, Limited.

The flared opening of the Quick-Clamp readily accepts prepared wires which are then firmly held by serrations in the clamp. As the screw is turned home positive contact is made.

Quick-Clamp Terminal Strips permit efficient, rapid assembly *without costly wire terminals*, and without bending the wire about a screw.

"U" type (Quick-Clamp) terminals both sides.



"U" type (Quick- Clamp) terminals one side solder connections on other side.

"U" type (Quick-Clamp) terminals one side connections through panel.

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- **Interchangeable Cord Sets**
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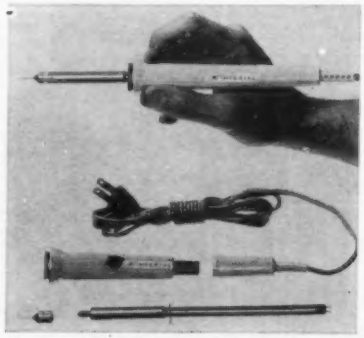

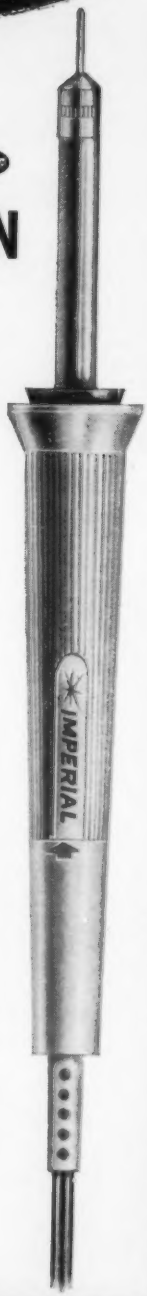

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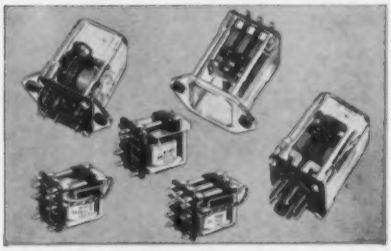

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— to relieve headaches due to line voltage variations

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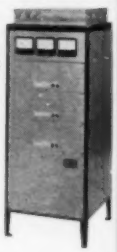

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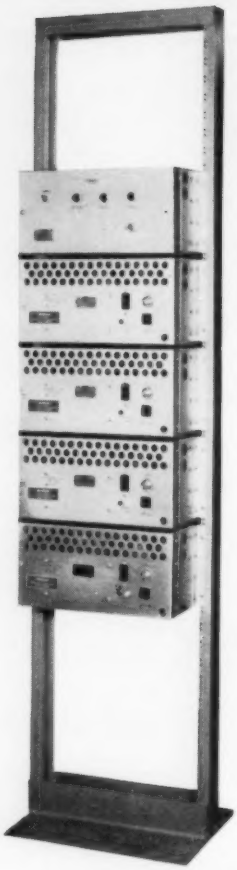
STATIC A.C. GENERATOR MODEL I-48E



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- Now in use with several major Canadian communications services.
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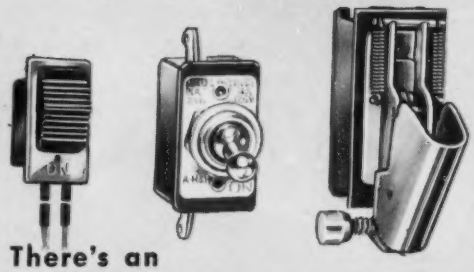

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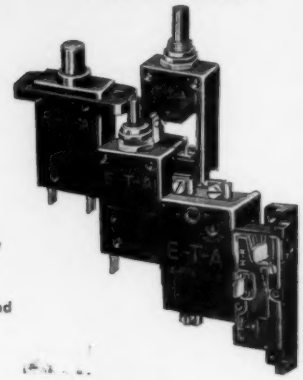

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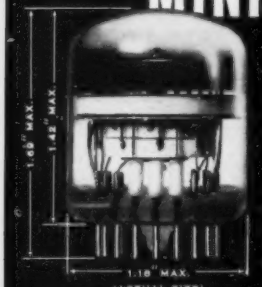
MINIATURIZED COUNTING TUBE

featuring routing guides for simplified bi-directional counting



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- Maximum anode current . . . 600 μA
- Maximum output at 5 kp/S with a 100 kΩ cathode load resistor and +50 V bias: 35 V
- Access to all ten cathodes

Incorporating a routing-guide system to provide glow direction sensing, this new cold cathode tube reduces the process of multi-stage, reversible, bi-directional counting and selecting to its simplest terms. This means fewer components, resulting in increased reliability and reduced costs. Ruggedly constructed, the GS10H follows the long Dekatron® tradition for reliability and performance.

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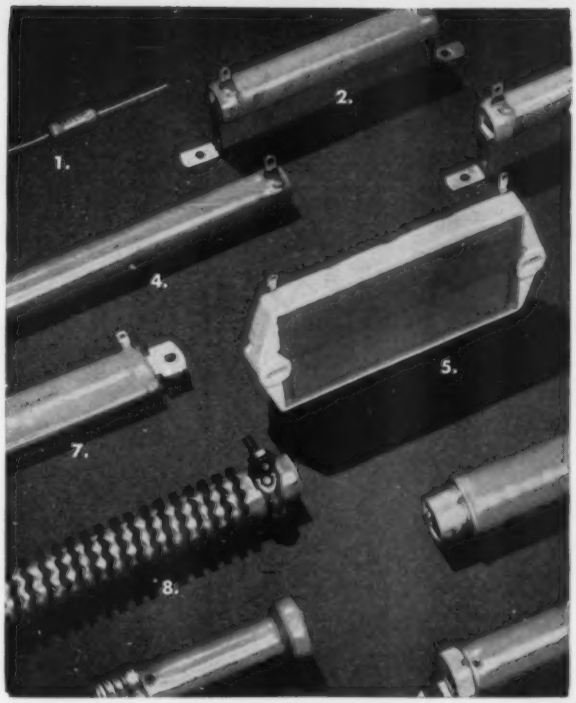

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Ward Leonard VITROHM resistors are available in a huge range of sizes, shapes and ratings . . . the most complete line ever offered by any manufacturer. Ward Leonard make their own ceramic cores . . . their own Vitrohm enamel and terminals . . . and even the resistance wire is specially drawn to Ward Leonard specifications. More than 19 separate checks are made on every single Ward Leonard resistor — so you're *certain* of reliability — and a tremendous stock of parts is maintained to meet your special or bulk requirements — fast.

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AIEE-IRE are considering merger in one international group

First steps were taken last month to consider consolidation of the two largest engineering societies in the world — the American Institute of Electrical Engineers and the Institute of Radio Engineers.

In a resolution passed by the boards of directors of both societies, a committee has been formed to determine the feasibility and form of such consolidation.

The proposed new organization would be international in scope and involve 150,000 engineers, scientists, educators and industrialists.

The announcement was made jointly by Lloyd V. Berkner, president of IRE and Warren H. Chase, president of AIEE. The resolution was first approved by the Board of Directors of IRE in New York on Wednesday, October 18. Approval of the Board of AIEE was given at the close of the Fell General Meeting of that organization in Detroit, Friday, October 20.

The resolution pointed out that "the advancement of the theory and practice of electrical and radio engineering and the educational and scientific objectives of both institutes may be better served by merger or consolidation . . . into one organization in which all present members would be included, and in which they would enjoy the same rights and privileges now conferred on them by their separate organizations."

A committee has been formed which is to submit a report to the boards of both societies not later than Feb. 15, 1962, for their approval "with a view to submission to a vote of the memberships of the two institutes and consummation, if so approved, by Jan. 1, 1962."

The committee also was authorized to prepare a proposed constitution and bylaws "in consultation with representatives" of both societies.

AIEE was organized in 1884 and has approximately 70,000 members from the United States and Canada. IRE, organized in 1912, has a total membership of 91,000 and is international in scope. Approximately 6,000 members belong to both societies.

Canada is second best customer for Sony Corp.

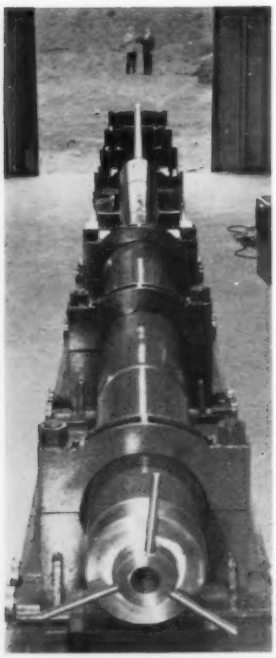
Masaru Ibuka, president of Sony Corp, told CEE last month that Canada is the second largest customer of the 125 countries to which his company exports its products. Canadian consumption represents one third of Sony's total exports.

Mr. Ibuka was in Canada on a ten-day trade mission with ten other executives from major business and industry in Japan.

Invited to comment on the recently established quotas on transistor radios and tubes, Mr. Ibuka said: "Although we basically believe in free trade, we recognize that some restrictions, such as quotas, are inevitable in certain areas.

"We know that to expand our world trade, we shall have to face stiff competition from the United States. We must, therefore, develop unique products. In the case of transistor radio exports, the U. S. had not sold this product in Canada when we entered the market, and the Canadian industry was not producing it. On the other hand, we are aware that our exports of receiving tubes caused problems in the Canadian industry."

On the subject of transistorized portable television receivers, Mr. Ibuka had this to say: "We are already exporting an eight-inch screen model to the U. S., but certain patent and service problems exist in the Canadian market. However, we expect to resolve these and start exporting these sets to Canada in the near future."



Computing Devices of Canada Ltd. is building an aerophysics research lab. near Stittsville, Ontario. The privately-owned lab. will do research in such fields as impact and penetration, winged vehicle stability, plasma radiation and communications, and high-G telemetry. In making the announcement, C. F. Hembery, president and general manager said, "While Canada at this time does not have any major high-speed aircraft, missile or space development program, it is considered essential that CDC participate in and establish a reputation in the field of aerospace technology. At left is a double chamber light gas gun being installed at the lab.

Communications in Canada

The December issue of CEE will feature several important articles on communications. Topics include information theory, spectrum management, radio frequency interference, stereo broadcasting, and equipment developments.

IRE Section meetings

Ottawa: Nov. 9; R. H. Tanner will describe the new Northern Electric Research and Development Labs.

Ottawa: Dec. 7; This is Armed Service Night. Further details may be obtained by contacting Ottawa Section chairman W. R. Conway, telephone 9-22828.

The tentative program schedule for the Ottawa Section lists two other meetings which will be of wide interest. They are Fellows Night on Jan. 11, and Students Night on Feb. 8.

Toronto: Nov. 13; "Infrared radiation: generation, detection and harmonic analysis," by Dr. H. Gush, University of Toronto. The meeting will be held in Hart House, 7 p.m.

Toronto: Nov. 27; This will be the second meeting of the season organized by the PGCS Chapter of Toronto Section. The subject will pertain to communications. Another meeting on communications is being organized by the PGCS Chapter for Dec. 11.

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1 mv at 1,000 mc!

or any rf voltage 1 mv to 10 v, from 500 KC to 1,000 MC. Measuring is as simple as "touch and read;" resolution is high, thermal drift errors are virtually eliminated!

Now, easily and dependably and with utmost accuracy, you can measure millivolts at rf frequencies — and on one simple-to-use instrument, hp 411A Voltmeter. This remarkable instrument has true linear operation (no correcting networks) and readings are presented on a large, mirror-backed linear meter. Temperature stability is such that there is virtually no change from 10° to 40° C.

Specifications alongside indicate basic features of this important new, time-saving instrument. Other special features include (a) matched diodes protected against burnout (b) probe temperature compensated for low drift (c) hp amplifier photochopper eliminating contact noise, guaranteeing high sensitivity and zero-drift freedom (d) extra probe tips available including a 500 KC to 250 MC tip; 100:1 Capacity Divider tip, and Type N Tee tip for coax use to 1,000 MC.

Why tolerate a complex, cumbersome voltmeter. Get a new hp 411A into action on your bench now!

Specifications

Voltage Range:	10 mv rms full scale to 10 v rms full scale in seven ranges. Full scale readings of 0.01, 0.03, 0.1, 0.3, 1, 3 and 10 v rms.
Frequency Range:	500 KC to 1 GC with accessory probe tips. Usable indications to 4 GC.
Accuracy:	1 MC to 50 MC, ± 3% of full scale; 50 MC to 150 MC, ± 6% of full scale; 500 KC to 1 GC, 1 db.
Meter Scales:	Two linear voltage scales, 0 to 1 and 0 to 3, calibrated in the rms value of a sine wave. Db scale, calibrated from +3 to −12 db; 0 db = 1 mw in 50 ohms.
Probe Tip Furnished:	411A-21E BNC open circuit tip, 500 KC to 500 MC. Shunt capacity less than 4 pf. Max. input 200 v dc. Input resistance at 10 MC typically 80 K ohms.
Galvanometer Recorder Output:	Proportional to meter deflection, 1 ma into 1000 ohms at full scale deflection.
Power:	115/230 v ±10%, 50 to 60 cps, 35 watts.
Dimensions:	Cabinet Mount: 11¾" high, 7½" wide, 12" deep. Rack Mount: 6$^{31}/_{32}$" high, 19" wide, 10⅜" deep behind panel.
Price:	hp 411A, (cabinet) $450.00. hp 411AR (rack mount) $455.00.

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SHOCKING NEWS FROM EIMAC: there's now a 250-watt tetrode that can withstand shock of 90G for 11 milliseconds and vibration from 20-750 cps at 10G, with maximum rated voltages applied! It's Eimac's 4CX250R (shown 1½ times actual size). This new tube in the 4CX250B family is electrically equivalent to Eimac's 7580. The difference: the 4CX250R is ruggedized for extreme environments—as are other members of the family. And what a difference! Call your Eimac representative or write: Power Grid Tube Marketing, Eitel-McCullough, Inc., San Carlos, Calif.

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